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REPORT ON WATER POLLUTION UPPER ARKANSAS RIVER BASIN

Colorado State Department of Public Health
Denver, Colorado

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July 1951

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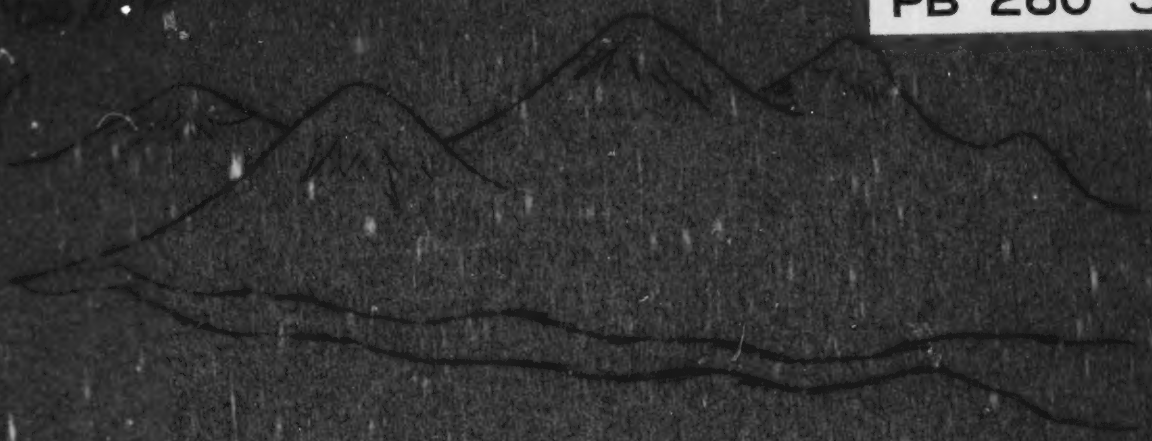

REPORT ON WATER POLLUTION

UPPER ARKANSAS RIVER BASIN

JULY 1951

A Joint Report Prepared by:

Colorado State Department of Public Health

and

Federal Security Agency - Public Health Service

in cooperation with

Colorado Game and Fish Department

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This report was prepared as a preliminary step in the development of a comprehensive program for the protection of waters in the Upper Arkansas River Basin. It is based on data that are readily available but are incomplete. Consideration is given to: historical background; economic development; uses of water resources; pollution contributed to water resources; damages to water resources from pollution; pollution prevention and abatement benefits; and pollution prevention measures in effect and still required.

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TABLE OF CONTENTS

Upper Arkansas River Basin Report

Page No.

Introduction - 1

Acknowledgments - 2

Summary - 3

Conclusions - 7

Recommendations - 9

Historical Background - - - - - - - - - - - - - - - - - - - 11

Physical Description - - - - - - - - - - - - - - - - - - - 12

Economic Development - - - - - - - - - - - - - - - - - - - 15

Uses of Water Resources - - - - - - - - - - - - - - - - - - 17

Pollution Contributed to Water Resources - - - - - - - - - - 24

Damages to Water Resources from Pollution - - - - - - - - - 30

Benefits Resulting from Pollution Prevention and Abatement - - - 32

Pollution Prevention Measures in Effect - - - - - - - - - - 34

Pollution Prevention Measures Required - - - - - - - - - - 39

Maps

Map No. 1. General Reference Map - - - - - - - - - - - - - - - 10

Map No. 2. Existing Primary Water Uses - - - - - - - - - - - - 16

Map No. 3. Sources of Municipal Pollution and Existing Treatment Facilities - 24

Map No. 4. Sources of Industrial Pollution and Existing Treatment Facilities - 24

Map No. 5. Municipal-Waste Treatment Needs - - - - - - - - - - 40

Map No. 6. Industrial-Pollution Abatement Needs - - - - - - - - 40

TABLE OF CONTENTS (Cont'd.)

Figures

Page No.

Figure 1, Population Growth Trends - - - - - - - - - - - - - - - - - 16

Figure 2, Stream System and Diversion Diagram - - - - - - - - - - 22

Figure 3, Sources of Pollution and Average Laboratory Results, Coliforms, Dissolved Oxygen, & Biochemical Oxygen Demand - - 26

Figure 4, Sources of Pollution and Average Laboratory Results, Turbidity, pH, & Alkalinity - - - - - - - - - - - - - 26

Tables

Table 1, Stream Flow Data - 14

Table 2, Municipal Water Supplies - - - - - - - - - - - - - - - - - 18

Table 3, Summary of Average Laboratory Results - - - - - - - - - - 27

Table A - Sources of Pollution - Municipal - - - - - - - - - - - - 25

Table B - Sources of Pollution - Industrial - - - - - - - - - - - 25

Table C - Existing Treatment Facilities - Municipal - - - - - - 35

Table D - Existing Treatment Facilities - Industrial - - - - - - 35

Table E - Adequacy of Existing Treatment Facilities - Municipal -37

Table F - Adequacy of Existing Treatment Facilities - Industrial-37

Table G - Progress in Construction of Pollution Abatement Facilities - - 37

Table H - Waste Treatment Needs - Municipal - - - - - - - - - - - 40

Table I - Industrial Waste Pollution Abatement Needs - - - - - - 40

Table J - Current Status of Municipal Action on Pollution Abatement Needs - - - 42

Table K - Current Status of Industrial Action on Pollution Abatement Needs - - - 42

Table L - Municipalities and Industries Needing Improvements for Abatement of Pollution - - - - - - 43

Appendix Page No.

Table 1a - Basic Data on Sources of Municipal Pollution - - - - 48

Review of State Water Pollution Control Laws - - - - - - - - - - 52

Water Pollution Investigation of the Upper Arkansas River Basin-54

Table 2a - Laboratory Data - Summary of Individual Results - - -56

INTRODUCTION

During the past several years the subject of stream pollution has received greater attention in Colorado than ever before. The attention has been focused on the water pollution problems of the State as a result of the concern expressed by public officials, professional and lay groups, and the general public. Concern on the part of all groups recognizes that unless measures are taken to abate pollution, the valuable water resources of the State will be seriously damaged and that the development of the basin's economy which is dependent on the water resources will be greatly hampered.

This report has been prepared as a preliminary step in the development of a comprehensive program for the protection of the waters in the basin. It is a summary of all information and data presently available related to the uses to which the water resources are put, the pollution reaching the watercourses and the damages resulting from pollution, the benefits which may result from pollution prevention and abatement, the pollution prevention measures now in effect and those which are required. It also contains a review of the State water pollution control laws and a summary of laboratory results from the water pollution investigation of the Upper Arkansas River and major tributaries conducted by the Colorado State Department of Public Health and the Colorado Game and Fish Department during the period October 15, 1950 - January 20, 1951.

The assembling of the data presented herein brings together all information collected by the State and other agencies to define the pollution problems. It is felt that this information will be useful to Federal and State agencies, municipalities and industries, and other interests concerned with the conservation and development of water resources. Further, it will serve to publicize the water pollution situation and direct the responsibility for needed corrective measures to municipalities and industries involved.

The report is also intended for use by the Public Health Service which is required by provisions of the Federal Water Pollution Control Act, Public Law 845, passed by the 80th Congress in June 1948, to cooperate with other Federal Agencies, with State and interstate water pollution control agencies, and with municipalities and industries in the preparation or adoption of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, and improving the sanitary condition of surface and underground waters.

It should be recognized that this report is based on data which are readily available, but are admittedly incomplete, for the consideration or development of a comprehensive water pollution control program for the basin. The deficiencies in data and lack of information indicated in the report are as significant as the presentation of available facts and statistics. They indicate the work which still needs to be accomplished by the designated State water pollution control agency for the development of a comprehensive program.

Data and knowledge now available are sufficient, however, to permit immediate solution of many pollution problems within the Upper Arkansas River Basin without awaiting results of additional surveys and studies. The list of pollution abatement projects which are included in Table L of this report represents presently known needs. Future studies and evaluations, however, may result in some changes in the estimations of requirements.

ACKNOWLEDGMENTS

This report has been prepared jointly by the Colorado State Department of Public Health and the Southwest Lower Mississippi Drainage Basins Office, Division of Water Pollution Control, Public Health Service, in cooperation with the Colorado Game and Fish Department.

Special acknowledgment is made to the Colorado Game and Fish Department for the assignment of personnel and equipment to the Colorado State Department of Public Health which assistance made possible the water pollution investigation of the Upper Arkansas River and tributaries.

Officials of the municipalities and industries contacted during the conduct of the pollution investigation contributed much information included in this report.

Indebtedness is expressed to the city of Salida and the city of Pueblo for laboratory space made available for the analyses of river water samples.

Reports of the following Federal agencies were consulted freeley for a considerable portion of the descriptive material contained herein:

- Department of Interior
    - Bureau of Reclamation
    - Geological Survey
    - Fish and Wildlife Service
    - Bureau of Mines
    - National Park Service

- Department of Army
    - Corps of Engineers

- Department of Agriculture

- Department of Commerce
    - Bureau of the Census

SUMMARY

The Upper Arkansas River Basin extends from the Continental Divide in central Colorado to the Colorado-Kansas boundary. It includes all or parts of 18 counties in southeastern Colorado and encompasses an area of approximately 26,000 square miles with an estimated 1950 population of 305,000.

The headwater region of the Arkansas Valley is mountainous. Eastward from the foot hills above Pueblo, the topography develops into the great plains region. The climatic conditions are characterized as sub-humid in the mountains where the precipitation averages slightly more than 20 inches and arid in the plains region where the average rainfall is less than 15 inches. Most of the stream discharge at the headwaters originates from light rainfall and melting snow. Intense rainfall of short duration in the plains region gives rise to flash floods and generally intermittent stream flows. Much of the river flow is diminished before it reaches the Kansas line by evaporation, channel absorption, and diversion for irrigation.

The discovery of gold in 1859 brought the original settlers to the basin. Mining then became the principal economic activity until the turn of the century when, as a result of the decreased mining activities, there began a gradual shift to agriculture and livestock raising. Agriculture now is the principal occupation in the basin. Mining, manufacturing and recreation also contribute a fair share of the basin's income.

The water resources are an important asset to the basin and are used mainly for public and industrial water supplies, irrigation and livestock watering, fishing and other recreational activities.

There are a total of 56 public water supplies in the basin. Eighteen supplies use surface sources and 38 use ground water sources. On the basis of population served, however, 80 percent is supplied from surface sources. Industrial water supplies are derived from both surface and ground water sources. Information regarding the total water use and relative importance of sources utilized is not complete for an estimate of this important water use.

The use of waters for irrigation is considered the principal water use in the basin. Approximately 322,000 acres of land are irrigated from the main stem of the Arkansas River. The use of streams and irrigation canals for livestock watering is also regarded as an important use associated with agriculture.

Recreational opportunities contribute a significant part of the State's income. The mountainous western portion of the basin offers excellent fishing and other inducements to tourists and campers. Conservation interests are active in conserving and developing the fish and wildlife resources and are strong advocates of stream pollution abatement.

Pollution reaching the waters of the basin originates mainly from municipal and industrial sources and also from natural sources such as sediment and dissolved salts and minerals.

Thirty-eight municipalities, including 3 public institutions, are regarded as potential sources of pollution for purpose of this report. Domestic wastes from a combined sewered population of 171,800 are discharged to the watercourses with partial or no treatment. Added to the domestic sewage are the wastes from many industries which use the municipal sewerage systems to dispose of their wastes. The lack of data regarding the volume and strength of the industrial wastes discharged to municipal sewers precludes an estimate of the total pollution load discharged from municipal sewerage systems.

In addition to the industries connected to public sewers there are 30 known industries which have outlets discharging directly to the watercourses. These industries include mining and ore processing, iron and steel mills, food processing plants, beet sugar refineries and a rendering plant. Several industries provide some waste control facilities, however, the majority discharge their wastes with no treatment. The lack of data regarding these sources of pollution also precludes an estimate of the total industrial pollution load discharged directly to the water courses. Results of a water pollution investigation made by the Colorado State Department of Public Health show, however, there has resulted a progressive deterioration of the river waters from the headwater to the Kansas line from the discharge of wastes from municipal and industrial sources.

Silt eroded from old mine tailings deposits cause damage to the fish resources of the Upper Arkansas River. The public health hazards associated with the use of polluted waters for sources of municipal supplies and irrigation purposes are of continual concern to the waterplant operators and health authorities.

Toxic and other deleterious substances originating from industrial wastes reaching waters used for livestock watering can result in serious economic loss to the extensive livestock raising enterprises.

The damages to the fish resources, irrigation facilities, and public and industrial water supplies, from silt pollution and dissolved minerals also present serious problems throughout the basin.

Numerous direct benefits to all principal water uses are associated with pollution abatement. The indirect and intangible benefits, however, are of equal or greater importance when evaluating a program of pollution control. Some of the indirect benefits, to which a monetary value cannot be assigned readily, include benefits to public health, aquatic life, recreation, and purely aesthetic considerations.

Pollution prevention measures in effect have been inadequate, as a whole, to protect the waters of the basin. Of the 38 municipalities listed as sources of pollution, only 18 provide some degree of treatment for their wastes. The domestic wastes from 116,500 persons, representing 68 percent of the total sewered population, are treated in primary treatment plants and the wastes from 7400 persons, or 4 percent of the total sewered population, are given a higher degree of treatment in secondary plants. There are no waste treatment facilities in 20 of the smaller communities having a population of 47,900 which represents 28 percent of the total sewered population. Of the 20 communities listed, 4 have no existing sewerage systems.

Information regarding existing industrial waste treatment facilities shows that even greater deficiencies exist in this field. Of the 30 industrial sources of pollution reported, 13, including mostly small scale dairies, food processing plants and 2 beet sugar refineries, have some type of waste control facilities. The remaining 17 industries, which discharge the bulk of inorganic type wastes produced in the basin, do not have waste control facilities.

The inadequacies of the existing waste treatment facilities leaves much to be desired in the way of providing adequate plant capacities and operation. About one-half of the existing municipal waste treatment plants, serving about 33 percent of the sewered population, are considered of adequate capacity; and less than one-third, serving about 37 percent of the sewered population, have satisfactory operation. Information regarding the remaining plants indicates that their adequacy with relation to capacity and operation is unsatisfactory or undetermined. None of the 13 existing industrial waste treatment facilities are considered adequate with relation to capacity or operation.

In spite of the increasing amount of pollution and inadequacies of existing waste treatment facilities, there has been little progress in the construction of pollution abatement facilities. During the 5 year period, 1946-1950, only 3 municipal treatment plants, to serve about 2700 persons, have been built. During the same period no industrial waste treatment facilities were constructed.

Coupled with the population increase and industrial development in the basin, the lack of adequate administrative facilities and control authority in the departments of the State government have been mainly responsible for the pollution situation in the basin. Efforts are now being directed toward a solution of the problem, however, and active steps are being taken by the State to provide adequate legislative authority and needed financial support for the administration of a water pollution control program.

An estimate of the pollution prevention measures required are based on admittedly incomplete data and, at best, should be considered as the basis of an initial water pollution control program.

Of the 38 municipalities considered as sources of pollution, 25, involving 112,500 persons or 65 percent of the total sewered population, need projects for abatement of pollution. The projects include 20 new plants to serve 47,900 persons, 2 enlargements or additions to existing plants serving 61,200 persons, and replacement of 3 plants serving 3,400 persons. Four municipalities require no projects and the needs for 8 with a sewered population of 57,000 are undetermined.

Information regarding the industrial waste pollution abatement needs is incomplete for an adequate evaluation of the problem. One iron and steel industry requires a new plant, 2 beet sugar refineries require enlargement of their waste control facilities, it is recommended that 14 smaller industries including dairies and food processing plants connect to city sewers, and the needs for the remaining 13 industries producing both inorganic wastes from mining and ore processing operations and organic wastes from food processing are undetermined.

Current status of action regarding the pollution abatement projects required for both municipalities and industries indicates only a few have taken cognizance of their responsibility and are taking action to provide for adequate treatment of their wastes.

In addition to the projects needed for pollution abatement in the basin, there is need for a comprehensive water pollution control program. This need can only be fulfilled, however, by the designation of a single State agency as responsible for all water pollution control activities. The designated agency can be expected to function effectively only through complete support of all those concerned with water pollution and to the extent adequate funds are provided for employment of trained personnel and for the needed facilities and equipment.

The deficiencies in existing State legislation in regard to water pollution control are recognized by all interests concerned with protecting the water resources for all water uses in the basin. Among the several undesirable features of the existing legislation is the division of responsibility among several departments of the State government. The State recognizes the deficiencies in this respect and is currently engaged in the task of developing suitable and comprehensive legislation for the purpose of defining the responsibilities and authority for a unified and concerted attack upon water pollution in the State.

The need for public support is essential for the promotion of an effective water pollution control program. A State program of public education advertising the damages resulting from pollution to all water uses, and the benefits accruing from restoration and protection of the waters will serve to create greater public demand for pollution abatement.

On the basis of available data which are admittedly incomplete for detailed cost estimate, the total initial cost for providing required municipal waste treatment plants and needed sewerage facilities, is estimated at $3,000,000 to $4,000,000. This estimate does not include the cost for needed industrial waste treatment facilities.

CONCLUSIONS

(1) The water resources of the Upper Arkansas River Basin are used primarily for irrigation, public and industrial water supplies, livestock watering, and for recreational purposes related principally with sport fishing opportunities. Limited water supplies for present needs and anticipated requirements for future developments emphasize the importance of pollution control for the protection and improvement of the available waters for all legitimate uses.

(2) New waste treatment facilities are required at a large majority of both municipal and industrial sources of pollution. Since 1946 there have been only 3 municipal waste treatment plants constructed within the basin. No industrial waste treatment facilities have been built during this period.

(3) The lack of sewage treatment facilities at State institutions has hindered both State and local authorities in encouraging the construction of treatment facilities. A specific example in the basin is the State Penitentiary at Canon City which is in need of a waste treatment plant since raw sewage is now being discharged to the Arkansas River.

(4) Inadequate legislation has resulted in most part from the enactment of fragmentary statutes applying to limited or specific pollution problems. Administration of a broad pollution control program is handicapped by the application of limited legislation developed through such procedures.

(5) Pollution control has been handicapped by the lack of "know how", especially as related to industrial waste treatment. Cooperative investigations and research projects between the responsible State agency, municipalities, and industries are essential for the solution of varied pollution problems and for the development and conduct of a sound program of pollution abatement.

(6) A progressive deterioration of the Arkansas River from the headwaters to the Kansas State line has resulted, in large part, from the uncontrolled discharge of wastes from municipal and industrial sources. Pollution from natural sources in the form of sediment and dissolved salts and minerals aggravate the existing conditions and give rise to serious problems of water use.

(7) The deficiencies in data and the gaps in information indicated in this report are as significant as the presentation of available facts and statistics. They indicate the work which still needs to be accomplished by water pollution control authorities to define completely the scope of the pollution problem.

(8) The benefits resulting from a program of pollution control will affect all legitimate water uses. Reduction of pollution by the construction of needed waste treatment facilities will permit the full utilization of the water resources essential to serve the needs of an increasing population, further industrial and agricultural expansion and the maximum development of recreational facilities.

(9) The effectiveness of many existing waste treatment facilities in accomplishing reduction of pollution reaching the watercourses of the basin leaves much to be desired. About one-half of the municipal plants are overloaded or obsolete and about two-thirds are subjected to unsatisfactory

operation. To achieve full benefit from existing plants and facilities constructed in the future, the program activities of the responsible State agency should be expanded to provide for surveillance of treatment plant operation and to promote training activities for plant operators.

(10) The lack of complete data regarding all sources of pollution precludes detailed cost estimates for providing required waste treatment facilities for pollution abatement in the basin. A preliminary estimate for needed municipal waste treatment facilities, however, indicates that the initial cost of treatment plants and sewerage facilities will be between $3,000,000 and $4,000,000. It is reasonable to assume that re-estimates of cost, when more complete data becomes available, may increase this figure appreciably. The estimate presented here does not consider the cost for providing any industrial waste treatment facilities.

RECOMMENDATIONS

It is recommended that:

(1) Comprehensive State water pollution control legislation which considers all water uses be promulgated and enacted without delay to assign the responsibility of water pollution control within a single department of the State government. The designated agency should be provided with adequate authority, financial assistance, and public support for the development and administration of comprehensive programs.

(2) Continued and accelerated efforts should be made by the designated State agency to secure supplemental data, particularly on industrial waste pollution, for the purpose of defining the problems more completely and to permit evaluation for instituting reasonable corrective measures.

(3) Municipalities and industries assume their responsibility for restoring and preserving the waters of the basin, and initiate construction of needed pollution abatement projects as outlined herein.

(4) All State-owned establishments and institutions provide adequate treatment of their wastes as a guiding example of the State's intent. The State Penitentiary at Canon City should take immediate steps for the construction of a required waste treatment plant.

(5) The following communities take immediate steps for the preparation of plans and construction of required waste treatment projects:

Canon City
Cripple Creek
East Canon
Florence
Fowler
HOLLY
Hugo
La Junta
Lamar
Las Animas
Leadville
LIMON
Manzanola
Rocky Ford
Salida
South Canon
Victor
Walsenburg

(6) The following communities with no public sewerage systems give consideration and initiate studies for the future installation of sewerage systems and adequate treatment plants:

Aguilar
Buena Vista
Fountain
Swink

(7) The cities of Pueblo and Trinidad provide required extensions of sewage collection facilities, encourage complete connection to city sewers for all sources of pollution now discharging directly to the watercourse, and take steps to provide the required additions to existing treatment facilities.

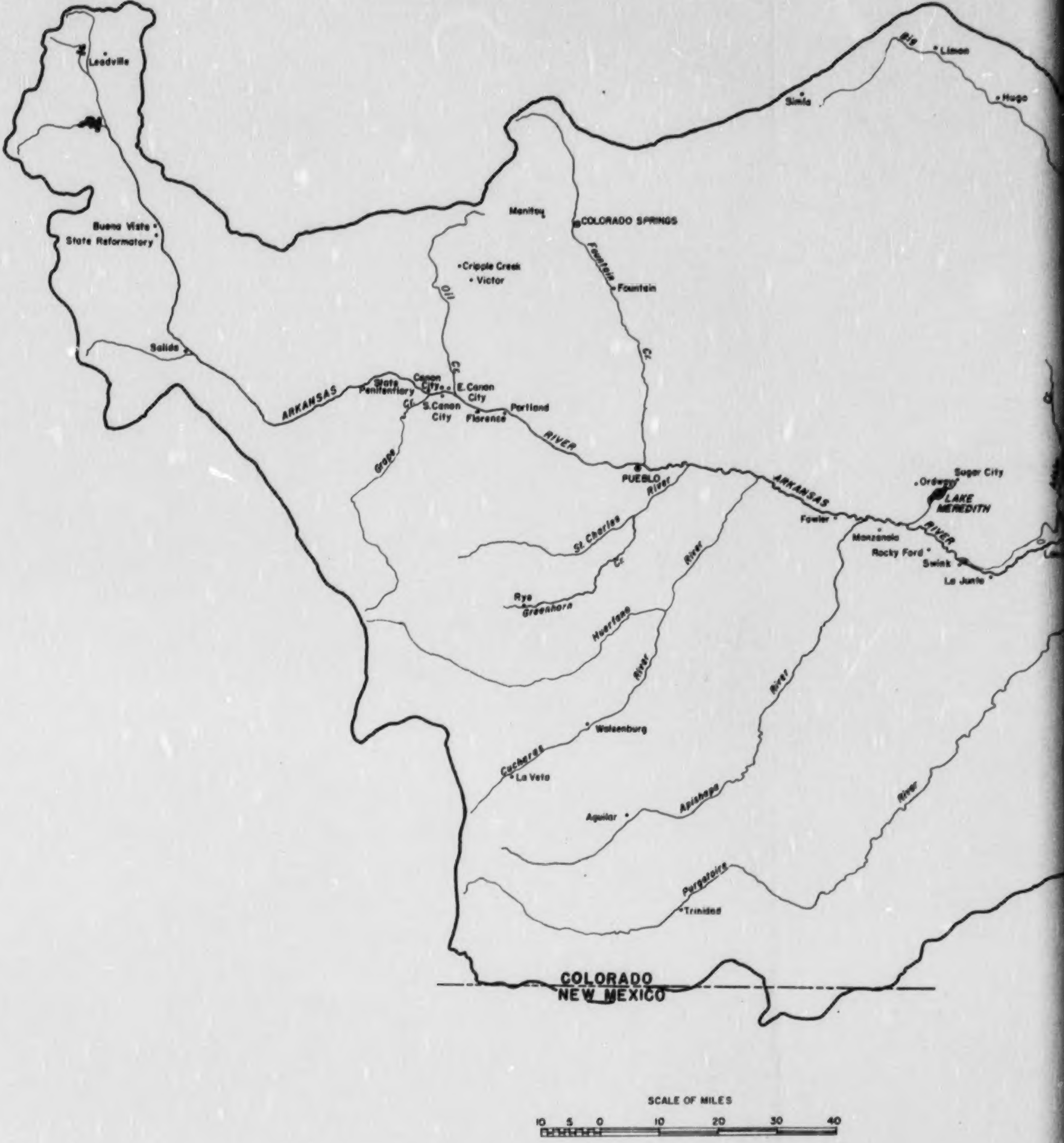
(8) The following communities, for which pollution abatement needs are undetermined, make studies of their facilities for the purpose of evaluating the adequacy of existing plants or the need for improvements:

Colorado Springs
Eads
Granada
La Veta
Ordway
Rye
Sugar City
Wiley

(9) All industries discharging wastes directly or indirectly to the waters of the basin should take cognizance of their contribution to the pollution of the watercourses and plan for needed corrective measures as required by down stream water uses. All industries accessible to municipal sewerage systems provide for the discharge of their wastes to the public system for ultimate treatment.

(10) Cooperative investigations and research projects between the State water pollution control agency, municipalities, and industries be initiated for the mutual solution of pollution problems and for a basis of instituting sound and equitable pollution abatement measures, especially in regard to industrial waste pollution.

(11) Public educational programs be initiated and promoted by the State water pollution control agency, as a means of publicizing the extent of pollution in the basin and informing the public of the damages resulting from pollution and benefits to be derived from pollution abatement.


Leadville
Buena Vista
State Reformatory
Salida
ARKANSAS
RIVER
State Penitentiary
Canon City
E. Canon City
S. Canon City
Florence
Portland
Grape
Cr.
Oil
Cr.
Cripple Creek
Victor
Manitou
COLORADO SPRINGS
Fountain
Fountain
Cr.
Simla
Big
Limon
Hugo
PUEBLO
St. Charles
River
Rye
Greenhorn
Cr.
Huerfano
River
Walsenburg
Cuchares
La Veta
Aguilar
Apishapa
River
Purgatoire
Trinidad
River
ARKANSAS
RIVER
Fowler
Manzanola
Rocky Ford
Swink
La Junta
Ordway
Sugar City
LAKE MEREDITH
COLORADO
NEW MEXICO
SCALE OF MILES
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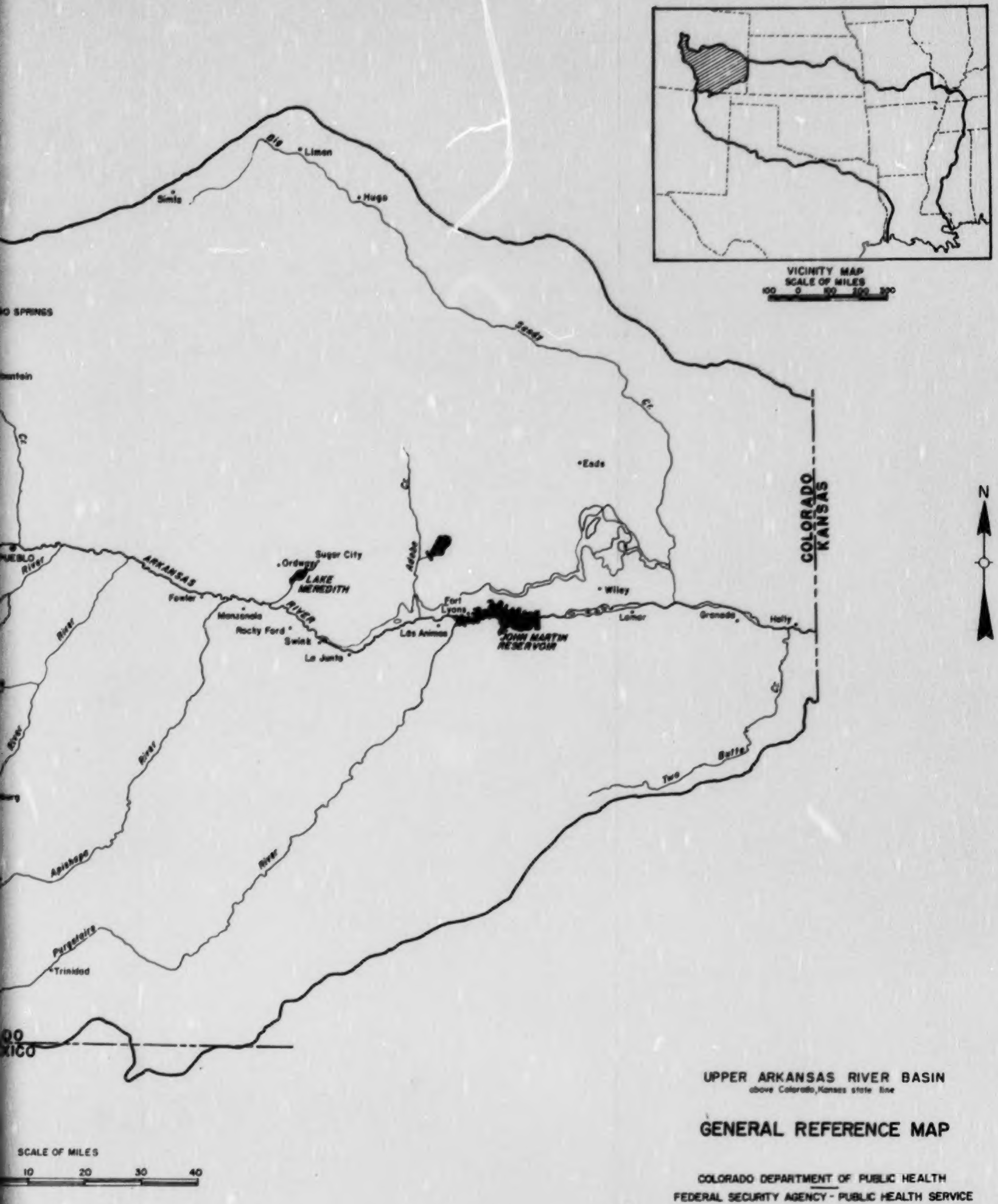

VICINITY MAP
SCALE OF MILES
100 0 100 200 300
Big
Limon
Simla
Hugo
Sandy
Cr.
SPRINGS
ountain
Eads
N
COLORADO
KANSAS
Sugar City
Ordway
LAKE MEREDITH
Adobe
Cr.
ARKANSAS
RIVER
PUEBLO
River
Fowler
Manzanola
Rocky Ford
Swink
La Junta
Las Animas
Fort Lyons
JOHN MARTIN RESERVOIR
Wiley
Lamar
Granada
Holly
Cr.
Two
Butte
River
River
River
River
Apishapa
Purgatoire
Trinidad
DO
XICO
SCALE OF MILES
10 20 30 40

UPPER ARKANSAS RIVER BASIN
above Colorado, Kansas state line

GENERAL REFERENCE MAP

COLORADO DEPARTMENT OF PUBLIC HEALTH
FEDERAL SECURITY AGENCY - PUBLIC HEALTH SERVICE

MAP No. 1

HISTORICAL BACKGROUND

The Upper Arkansas River Basin was a part of the Louisiana Purchase acquired by the United States from France in 1803. Many Spanish explorers visited the region principally during the period 1760-1780. However, the first official exploration by the United States was that of Lt. Zebulon Pike in 1806-1807. Until the latter 1850's and early 1860's the area was frequented primarily by Indians, trappers, hunters, traders, and explorers. Notable explorations of the area by the United States include those of General John C. Fremont, 1845-1853, and Captain John W. Gunnison in 1853. With the discovery of gold in the area in 1859 the first permanent settlements were established.

The early history of Leadville is colored with stories of conquest, intrigue, fortunes and murders. The news of gold discovery in the mountains above Leadville brought hoards to the area and at the height of the boom, about 1878-1879, it is reported that 40,000 persons migrated there. The real importance of Leadville, however, resulted from the enormous amounts of silver and lead mined in the area.

Pueblo, since it was established as a post in 1842 by a company of traders, has grown steadily to become the leading industrial and transportation center in the Upper Arkansas Valley.

The principle of irrigation was pioneered in the basin by George Washington Swink. He settled at the present location of Rocky Ford in 1857. In two years he plotted out the town, setting out hundreds of trees and cutting small ditches along the side streets through which Arkansas River water was diverted. Rocky Ford is now known across the continent for the quality of melons grown on its irrigated farms.

Although a few found their fortune, a majority of the immigrants, attracted to Colorado by the mining booms, either left discouraged or turned to agricultural pursuits along the streams and undertook to produce foodstuffs required to support the expanding population. There is still some mining near the source of the Arkansas at Leadville, but most of the land is devoted to irrigated and dry farming or to livestock raising.

PHYSICAL DESCRIPTION

Geography

The Upper Arkansas River Basin, which lies entirely within the State of Colorado, is approximately 340 miles long and has a maximum width of 170 miles. It comprises a drainage area of 26,140 square miles and encompasses all or parts of 18 counties on both sides of the river.

The Arkansas River rises in the high mountains in the vicinity of Leadville, at an elevation in excess of 13,000 feet. From Leadville it flows in a southerly direction, turns east at Salida, emerges from the Royal Gorge at Canon City, enters the high plains area at Pueblo, and, if it escapes being used for irrigation, it leaves the State some 350 miles from its source. Major tributaries downstream from Pueblo are Fountain Creek and the St. Charles, Huerfano, Apishapa and Purgatoire Rivers. The largest contributor, in view of drainage area and runoff, is the Purgatoire River. A regulatory reservoir (John Martin) is located on the main stem just below its junction with the Purgatoire River.

Topography and Geology

The Upper Arkansas River Basin may be divided topographically into three general regions; the mountainous region, the foot hills and the high plains. The mountainous region which comprises approximately 17 percent of the total basin area is at an altitude above 8,000 feet. About 45 percent of the area is at elevations from 5,000 to 8,000 feet and is mostly hilly but contains small scattered tracts of land suitable for cultivation. The remaining 38 percent of the basin lies between 3,500 and 5,000 feet elevation and consists of fairly level plains used almost entirely for agricultural purposes.

Geologically, rock formations of the Arkansas River Basin may also be divided into several classifications. The area above Canon City consists almost entirely of complex igneous and metamorphis rock of Pre-Cambrian and Tertiary age overlain in part by intrusive material, glacial moraine and terrace deposits. Below Canon City and over the greater part of the Eastern slope occur a series of sedimentary rocks.

Because the prevailing hard igneous rocks in the mountain regions are not easily eroded, there is little silt or dissolved mineral matter contributed to the river water above Canon City from this source. The river in this section does receive an appreciable amount of silt from the erosion of mine tailings dumps located along its banks.

Probably the most important of the sedimentary beds is the Dakota sandstone, which, in general, forms a large water-bearing stratum underlying most of the lower part of the basin. It is these sedimentary layers that are the most easily eroded rock in the Eastern Slope area and contribute most of the silt transported by the Arkansas River and its tributaries.

Climate and Hydrology

Wide variations of climate occur within the Upper Arkansas River Basin, The high mountain regions have a subhumid climate characterized by less extreme temperature variation, higher precipitation than in the plains region, protracted cold spells and a decrease in mean temperature with increased altitude. The average annual precipitation in the mountainous region varies from 18.63 inches at Leadville to a low of 8.78 inches at Buena Vista. The average annual temperature at Leadville is 35.6° F., with a maximum of 86° F. and a minimum of -29° F.

From the front range of the Rockies to the Colorado-Kansas boundary, the climate is arid. This climate is characterized by low humidity, reasonably long growing season, extreme daily and seasonal temperature ranges, little snow, frequent hail, and high rainfall intensity with the major portion of the annual precipitation occurring in the summer months. Precipitation in the plains region has an annual average of 13.75 inches with Lamar recording a high of 16.05 inches and Pueblo a low of 11.67 inches. Although 83.2 percent of the annual precipitation occurs during the growing season (April through October) the average rainfall is insufficient for crop production and consequently irrigation is practiced extensively. Temperatures in the plains region range from a minimum of -30° F. to a maximum of 114° F. Average annual temperature of the region is 53° F. The average frost free period varies from 83 days at Leadville to 173 days at Pueblo.

Stream flow data at various gaging stations on the Upper Arkansas River and its major tributaries are shown in Table 1. The runoff varies widely in the basin with flows being greatly depleted in the plains region below Pueblo because of diversion for irrigation, channel absorption and evaporation. The stream flow pattern in the Upper Arkansas is such that the maximum stream flows occur in June and July and sometimes August, following the snow-melt in the mountains. Streams are flashy and readily respond to intense rainfall on the upper tributaries. Low flows occur during the winter months from November through February and March and sometimes April. As shown in Table 1, there are periods of no flow. For purposes of stream flow analyses, low flow frequencies computed for summer and winter flow conditions are valuable aids. The demands of irrigation together with return flows bring about little apparent relationship between stream flows at successive downstream stations and make accurate estimates of flow difficult except at established rated gaging stations. Flow at any point between gaging stations is problematical during the irrigation season. The operation of the John Martin reservoir near Lamar will serve to regulate stream flows in the Arkansas River below that point, depending upon the irrigation demands and return flows above any given point under consideration.

The flow pattern of low winter flows and high summer flows brings about critical dilution problems in the winter with regard to water pollution control.

Table 1 - UPPER ARKANSAS RIVER BASIN

STREAM FLOW DATA

Watercourse - Gaging Station	Years of Record	Average Annual Runoff		Maximum Monthly Runoff		Minimum Monthly Runoff	
		Vol. in Acre-ft.	Aver. Rate c.f.s.	Vol. in Acre-ft.	Aver. Rate c.f.s.	Vol. in Acre-ft.	Aver. Rate c.f.s.
Arkansas River							
Canon City	42	458,600	633	204,200	3,431 (19,000)	6,410	108 (82)
Portland	10	571,900	790	243,100	4,084 (16,000)	8,890	149 (71)
Pueblo	40	513,900	710	397,000	6,670 (103,000)	4,760	80 (18)
Nepesta	22	531,600	734	310,500	5,049 (180,000)	5,450	92 (0)
La Junta	33	217,500	300	607,000	10,198 (200,000)	386	7 (0)
Las Animas	10	228,700	316	298,600	4,855 (187,000)	584	9.5 (8)
Caddoa	11	346,300	478	433,900	7,290 (180,000)	15	.27 (0)
Lamar	31	198,000	273	684,000	11,491 (165,000)	67	1.1 (0)
Holly	34	253,400	350	585,000	9,828 (136,000)	68	1.1 (0)
Fountain River							
Pueblo	10	55,000	76	45,240	736 (35,000)	42	.71 (0)
St. Chas. River							
Pueblo	7	23,200	32	35,710	600 (56,000)	14	.23 (0)
Huerfano River							
Undercliffe	11	42,400	59	85,610	1,392 (26,600)	0	.0 (0)
Apishapa River							
Fowler	13	30,900	43	31,510	529 (14,700)	54	.91 (0.1)
Purgatoire Riv.							
Trinidad	30	68,200	94	77,080	1,295 (45,400)	107	1.8 (0)
Highland Dam	18	79,700	110	170,800	2,869 (60,000)	0	.0 (0)

Figures in (Parenthesis) are maximum or minimum flows recorded.

ECONOMIC DEVELOPMENT

Population

The population of the basin has shown a steady increase from the 73,000 inhabitants of 1880. Generally, the counties in the mountainous region have declined in population due to the reduction of mining. Concurrent with the decrease in population in the region supported chiefly by the mining industry, a gradual population increase occurred in most of the agricultural areas of the Arkansas Valley. As shown in Figure 1, there has been a continual marked increase in urban population, but the rural population has decreased after 1920. Based on the national growth rate and on the assumption that the Fryingpan - Arkansas Development becomes a reality, the population of the basin is expected to reach 370,000 by the year 2000. Present population of the basin is estimated to be 305,000 of which 60% is urban and 40% is rural.

Basin Economy

The most important industries in the basin are agriculture, manufacturing, mining, and tourist industry. Agriculture has been a major occupation since the advent of irrigation and dry-land farming about 1859. The development of large cattle ranches followed in 1868. Irrigation farming is practiced in the valleys of the Arkansas River and its tributary streams. The main areas of irrigated lands are located in the high plains region below Pueblo. Within this region there are approximately 40 major irrigation ditches and canals which divert water from the river for the irrigation of 322,000 acres of farm land. Diversions are made for storage as well as for direct irrigation. Dry-land farming is practiced on the remote unirrigable lands of the high plains. Livestock raising is carried on in conjunction with farming. The principal crops are forage, sugar beets, melons, fruit, grains, and truck crops.

On the basis of 1939-1944 average crop prices, the average gross crop return in the irrigated area ranged from $30.00 to $40.00 per acre whereas the average for non-irrigated crop land in adjacent areas was less than $5.00 per acre. These figures do not represent the value of livestock raised in the basin.

Mining, with its principal products of coal, molybdenum, gold, silver, copper, lead, and zinc, ranks next to agriculture as the principal activity in the basin. Molybdenum, with a reserve said to exceed 100,000,000 tons, ranks first among mined products. Many other metal and non-metals are found in varying quantities throughout the basin. Except for an upsurge of activity during the war years, mining has decreased in importance and the overall activity in this field has declined in recent years.

The presence of abundant raw materials provides a manufacturing potential which, to date, has been slow in developing. The largest and most outstanding manufacturing plant in the valley is the steel plant of the Colorado Fuel and Iron Corporation at Pueblo. Other major industrial establishments are the Golden Cycle Corporation which operates a large mill at Cripple Creek for the treatment and extraction of gold and other ores, and the Ideal

Portland Cement Company which operates a plant at Portland. Other industries located within the basin include beet sugar refining, brewing, meat packing, canneries, brick manufacturing, flour milling, grain and alfalfa milling, and milk and milk products.

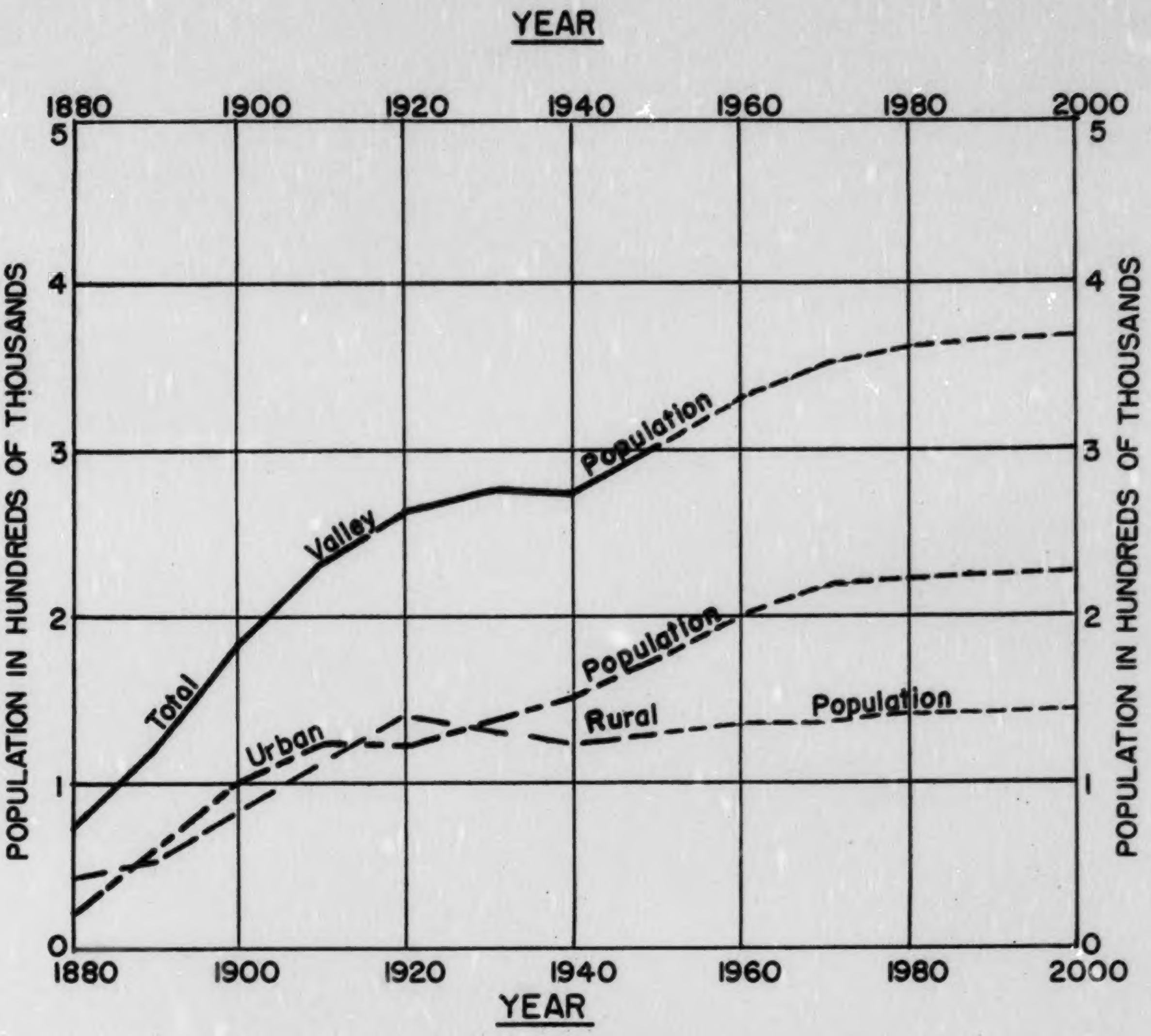
Although still in its infancy, recreation, including the tourist industry, is developing into one of Colorado's top sources of business income. During 1949 it was responsible for some $200,000,000 in State income. The mountainous region above Salida is attracting increasing numbers of tourists yearly. Besides its majestic scenery, this area also has fishing, hunting, camping, skiing, and other sports to offer the vacationist.

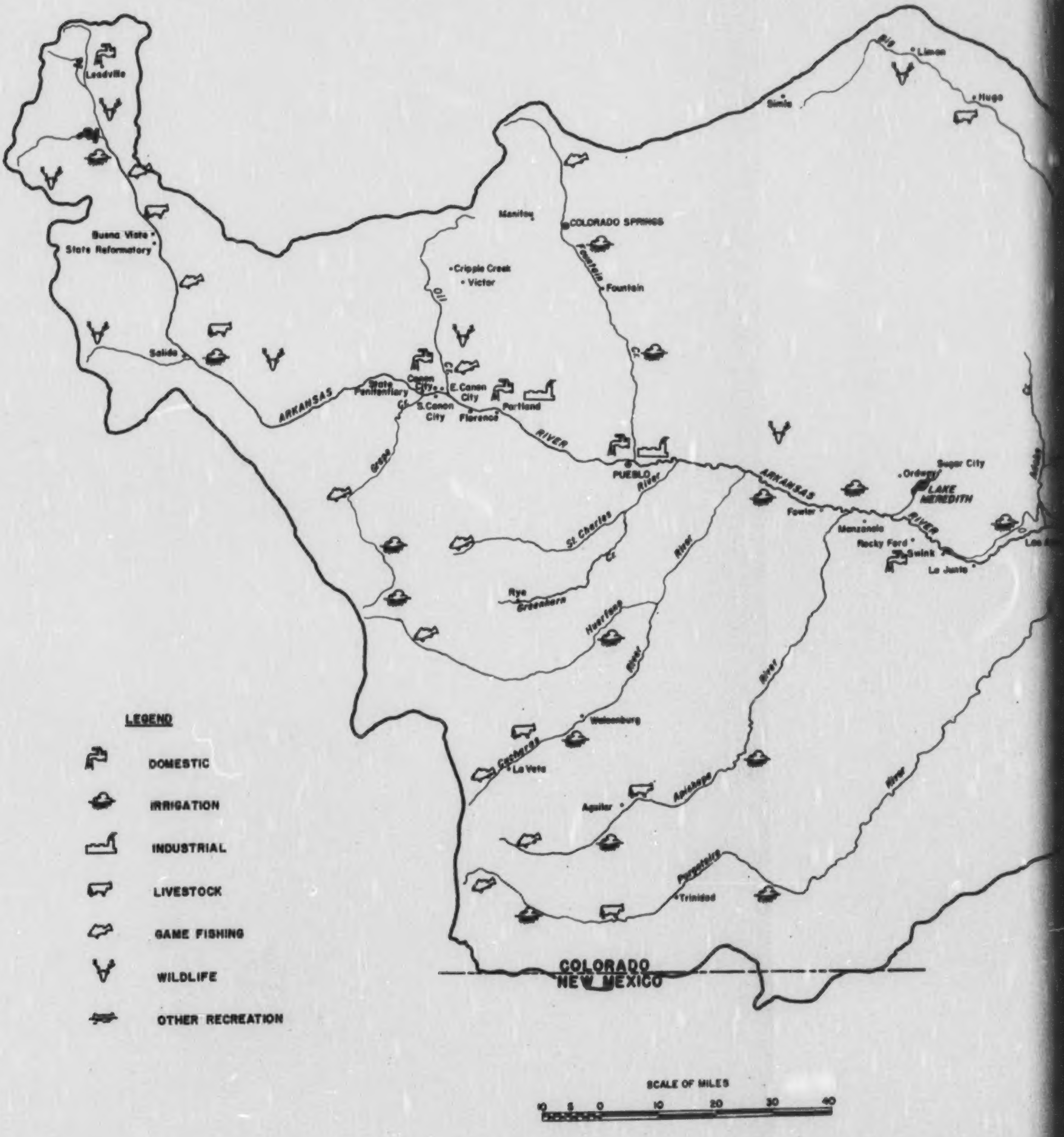
The per capita general property assessed valuation within the basin in 1940 was $974.00. The average county tax totaled 32.62 mills for 1944. Bank statistics reveal a poor ratio of deposits to loans and discounts. It is evident that, although the people possess capital there is lack of investment opportunities necessary to provide optimum development of the area, Money is lying idle in banks and not creating wealth. The ratio of deposits of loans and discounts in 1941 was 5.1 to 1, compared to a State ratio of 3.1 to 1.

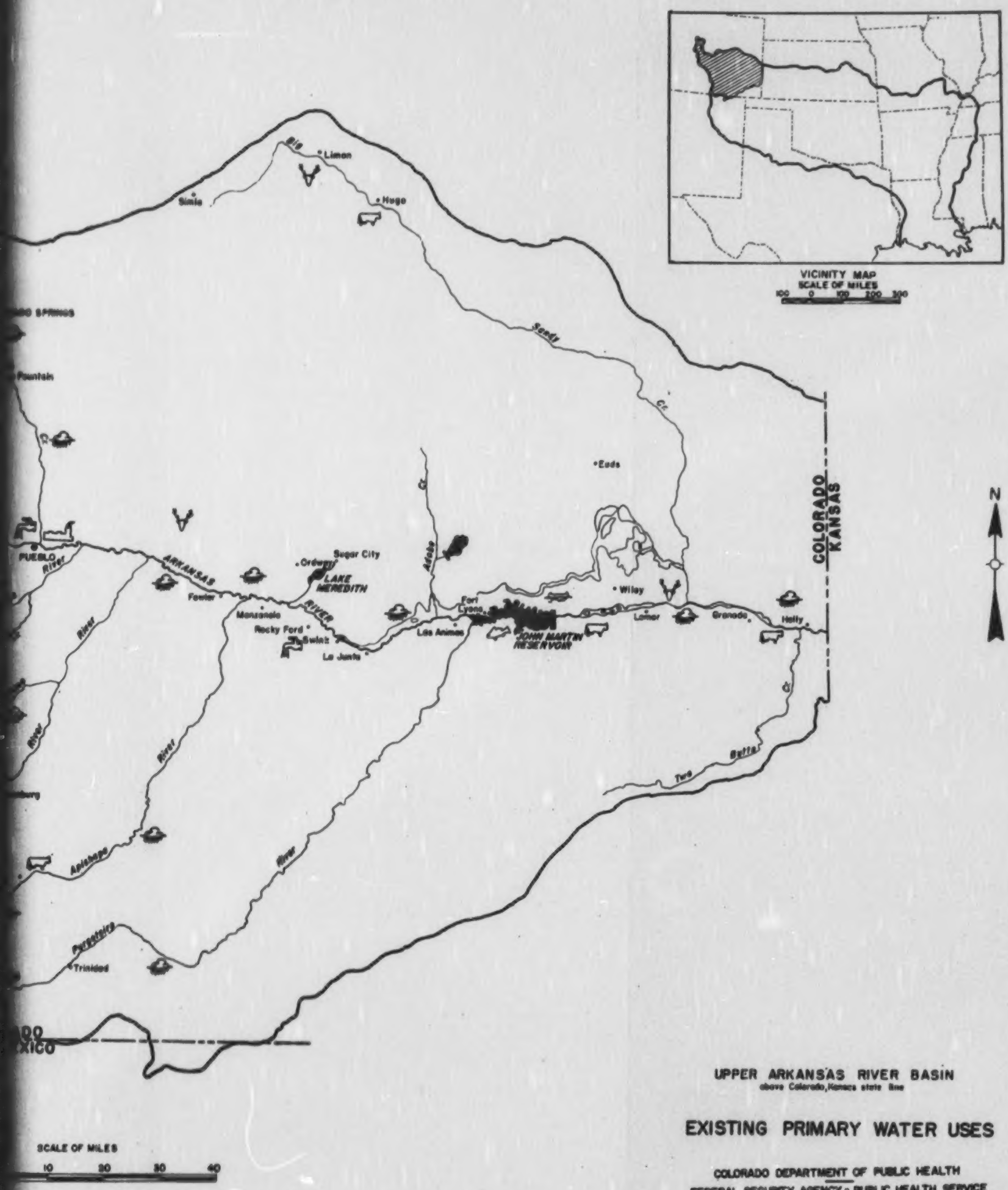
Figure 1.

POPULATION GROWTH TRENDS

ARKANSAS VALLEY
COLORADO




Leadville
Buena Vista
State Reformatory
Salida
Manitou
COLORADO SPRINGS
Fountain
Cripple Creek
Victor
Oil Cr.
State Penitentiary
Canon City
E. Canon City
S. Canon City
Florence
Portland
Grape Cr.
ARKANSAS
RIVER
PUEBLO
St Charles River
Rye
Greenhorn Cr.
Huerfano River
Walsenburg
Cucharas
La Veta
Aguilar
Apishapa River
Purgatoire
Trinidad
River
Big Sandy
Limon
Hugo
Simla
Sugar City
Ordway
LAKE MEREDITH
Fowler
Manzanola
Rocky Ford
Swink
La Junta
Las A
Adobe Cr.
COLORADO
NEW MEXICO
LEGEND
DOMESTIC
IRRIGATION
INDUSTRIAL
LIVESTOCK
GAME FISHING
WILDLIFE
OTHER RECREATION
SCALE OF MILES
10 5 0 10 20 30 40


VICINITY MAP
SCALE OF MILES
100 0 100 200 300
Big
Limon
Simla
Hugo
Sandy
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ARKANSAS
RIVER
Sugar City
Ordway
LAKE MEREDITH
Adobe
Cr.
Fowler
Manzanola
Rocky Ford
Swink
La Junta
Fort Lyon
Las Animas
JOHN MARTIN RESERVOIR
Wiley
Lamar
Granada
Holly
Cr.
Two
Butte
River
River
River
River
Apishapa
Purgatoire
Trinidad
ADO
XICO
SCALE OF MILES
10 20 30 40

UPPER ARKANSAS RIVER BASIN
above Colorado, Kansas state line

EXISTING PRIMARY WATER USES

COLORADO DEPARTMENT OF PUBLIC HEALTH
FEDERAL SECURITY AGENCY - PUBLIC HEALTH SERVICE

MAP NO. 2

USES OF WATER RESOURCES

Water uses in the Upper River Basin reflect, in large part, the economic activities of the region. The principal water uses considered pertinent to the subject of water pollution control in the basin include the following: municipal and industrial water supplies; agricultural, including irrigation and livestock watering; recreation; fish and wildlife; and final waste disposal. Map No. 2 shows the existing primary water uses along the principal watercourses within the basin.

Municipal and Industrial Water Supplies

Table 2 shows a summary of the municipal water supplies in the basin obtained from surface and ground water sources. There are 56 municipal water supplies in the basin serving approximately 193,500 persons with an average of 55.5 million gallons of water daily. Of the total number, 18 public supplies use surface waters as sources of supply to serve nearly 155,000 persons with an average of 47.0 million gallons of water daily. The remaining 38 supplies utilize underground sources, including wells or springs, to serve approximately 38,500 persons with an average of 8.5 million gallons of water daily. Pueblo, the largest city in the basin with 1950 population of 63,561 and center of considerable industrial activity, alone uses an average of 24 million gallons of water daily diverted from the Arkansas River, representing a daily per capita consumption of 380 gallons. It is apparent from these data that about 80 percent of the population served by public water supplies use water from surface sources and that surface water resources of the basin must be relied upon to furnish increased demands resulting from growing populations and expanding agricultural and industrial activities.

Complete data regarding the industrial water use throughout the basin are not available. Some indication of the water needs of industry is represented, however, by the requirements and problems of several plants for which data are available. It should be noted that a great many of the industries are small scale enterprises utilizing municipal water supplies. Their water requirements are included in the high consumption data for these public supplies.

The Southern Colorado Power Company at Canon City diverts about 19.0 M.G.D. from the Arkansas River for cooling purposes only. Boiler water is obtained from wells and requires softening to render it suitable for use.

The Lincoln Packing Company, the Southern Colorado Power Company, and the Colorado Fuel and Iron Corporation, at Pueblo, have their own water supplies. The Lincoln Packing Company, a meat packing concern, has three drilled wells. No pumpage figures are available. The water for boiler use is treated by zeolite. The Southern Colorado Power Company obtains water from wells, which have a total capacity of 0.36 M.G.D., and from diversions from the Arkansas River. Well water is softened for boiler use and the net annual consumption amounts to 1,835,000 gallons. The amount of cooling water diverted from and returned to the Arkansas River is not reported.

The Colorado Fuel and Iron Corporation obtains water from the Arkansas River through the Minnequa Canal, the St. Charles Flood Ditch, and runoff

Table 2 - UPPER ARKANSAS RIVER BASIN
MUNICIPAL WATER SUPPLIES

Municipality	Population Served (1950)	Average Pumpage M.G.D.	Average Consumption gals./cap./day
	From Surface Water Sources		
Buena Vista	776	0.075	100
Canon City	10,000*	2.5	250
Colorado Springs	45,269	10.0	220
Cripple Creek	800	1.0	125
East Canon	(700)	Supplied from Canon City	
Florence	2,765	0.165	60
Green Mountain Falls	104 1/	--	--
La Veta	696	0.10	145
Leadville	4,078	1.0	245
Manitou	2,611	0.75	290
Portland	205	0.47	2,300 2/
Pueblo	63,561	24.0	380
Rocky Ford	4,950	1.25	250
South Canon	(1,586) 1/	Supplied from Canon City	
Trinidad	11,600	4.0	350
Victor	677	0.03	45
Walsenburg	5,570	1.50	270
Wiley	500	0.20	400
	From Ground Water Sources		
Aguilar	1,400	0.06	43
Branson	200 1/	--	--
Calhan	378 1/	--	--
Cheraw	450 1/	--	--
Coal Creek	195 1/	--	--
Cokedale	250 1/	--	--
Crowley	380 1/	--	--
Delagua	422 1/	--	--
Eads	1,011	0.05	50
Fort Lyons	1,500	0.15	100
Fountain	711	0.07	100
Fowler	1,016	0.50	500
Granada	547	0.075	140
Hartman	168 1/	--	--
Haswell	163 1/	--	--

Table 2 (Cont'd)

Municipality	Population Served (1950)	Average Pumpage M.G.D.	Average Consumption gals./cap./day
	From Ground Water Sources (Cont'd)		
Holly	1,244	0.45	360
Hugo	885	0.20	225
Kit Carson	400 1/	--	--
La Junta	7,900	2.85	360
Lamar	5,468	0.82	150
Las Animas	2,422	1.5	620
Limon	1,438	0.15	100
Manzanola	544	0.035	65
Monument	128 1/	--	--
Olney Springs	275 1/	--	--
Ordway	1,291	0.035	27
Palmer Lake	264 1/	--	--
Poncha Springs	100 1/	--	--
Ramah	143 1/	--	--
Rockvale	381 1/	--	--
Rye	260	0.05	190
Salida	4,516	1.50	330
Silver Cliff	239 1/	--	--
Simla	504	0.05	100
Sugar City	521	0.06	115
Swink	330	0.018	55
Westcliff	426 1/	--	--
Williamsburg	97 1/	--	--

* Includes E. Canon and S. Canon

1/ 1950 Census Population

2/ Includes industrial use by Ideal Portland Cement from Salt Creek. The net consumption reported for the period 1927 - 1940 averaged 32.6 M.G.D. More recent estimates based on waste discharges indicate this amount exceeds 50.0 M.G.D.

The Lamar Power Company at Lamar obtains water for cooling purposes from wells which supply between 2.5 and 6.0 M.G.D.

A group of several other smaller industries, including railroad shops and canneries, use about 50,000 gallons daily from well supplies.

Irrigation of lawns and gardens is the largest single item affecting the high rate of municipal water consumption for the communities in the basin. Municipal and industrial water supplies, in general, need supplemental quantities and improvement in quality. The most critical area in this respect is the plains area, extending from Pueblo to the Colorado-Kansas State line, where the heaviest concentration of industry and population is located. Water supplies in this area are barely adequate at present and shortages are expected in most of the large cities. The quality of surface waters is poor from a bacteriological and chemical standpoint, and extensive treatment is required to provide potable water for domestic purposes. In some cases the Arkansas River water requires treatment for industrial purposes also.

Along the main stem of the Arkansas River ground water sources supply an estimated 400-600 wells used for supplemental irrigation water, and along some tributary valleys it is the sole source of irrigation and municipal supplies. In common with the river water, the shallow ground water in the alluvium along the main stem of the Arkansas River becomes progressively harder and more highly mineralized until it becomes unfit for some purposes by the time it reaches the Kansas State line. This condition has created difficult problems of municipal water supply for the communities along the river, most of which generally are faced with the choice of using exceptionally hard water either from the river or from shallow wells. Towns that use deep well supplies obtain relatively softer water from the underlying sandstone formations.

The anticipated increase in population of nearly all the communities in the basin expected from agricultural and industrial development would create a demand for public water in excess of the amount which can be supplied from existing sources.

Agricultural Use

Agriculture is the most important industry of the basin. Cultivated lands comprise 10 percent of the area of which about one fourth or 322,000, acres, is irrigated from the main stem of the Arkansas River. About 87 percent of the land area, including timberland, is used for livestock grazing.

Irrigation is the principal water use in the Arkansas Valley in the region extending from Canon City to the Colorado-Kansas boundary. Early irrigation coincided with available stream flows. As irrigation farming was expanded unregulated stream flow could not supply the demand which developed. Consequently between 1890 and 1910, three reservoirs in the headwaters area and 11 off-stream reservoirs below Pueblo were constructed. In 1949, the John Martin Reservoir on the Arkansas River was completed for conservation storage and flood control. It provides irrigation storage capacity of 420,000 acre-feet.

More than 40 canals and ditches supply irrigation water to lands in the valley between Canon City and the Colorado-Kansas State line. Figure No. 2 shows the principal irrigation systems along the Arkansas River.

The amount of irrigation water available for the existing irrigated lands varies considerably from year to year. Seldom is the supply adequate for maximum crop production and water shortages as high as 78 percent of crop requirements have occurred. Normal stream flows in the Arkansas River and its tributaries during the summer season are used entirely for irrigation purposes as well as part of their flood and winter flows which are conserved in the reservoirs. Return flows in excess of 200,000 acre-feet annually reach the river between Pueblo and Holly for re-use by irrigation interests. The amount of land under irrigation has not increased in recent years as it is dependent upon the available water supply which is presently utilized to the maximum. Supplementing the irrigation water supply depends upon conservation and regulation of existing supplies for more efficient use, and obtaining new water supplies from adjacent river basins. Diversion of additional water into the basin from the Colorado River drainage is proposed by the Bureau of Reclamation as a means of supplementing the present supply for future needs and development of the basin.

Conservation of the present water supplies takes into consideration protection of the waters to permit optimum utilization for all primary uses. The discharge of untreated or inadequately treated municipal sewage and industrial wastes into the streams during the irrigation season give rise to problems in pollution control which under other conditions might not be considered as especially significant. Where sewage polluted waters are applied to growing crops, the potential public health hazards associated with the spread of water-borne diseases must be considered.

Livestock and livestock products are important components of the agricultural economy of the basin. As stated previously, about 87 percent of the land area is used for stock grazing. During the summer months numerous head of livestock are taken to higher altitude areas to graze, usually in the national forests. Large numbers of cattle, sheep, and lambs are fattened for market in the lower irrigated areas.

The need for adequate sources of suitable water to support and promote the development of the livestock industry is recognized in all fields of water resources conservation and development. The protection of surface waters that are accessible for livestock watering from toxic and other harmful pollution is necessary in the basin to insure optimum growth of the stock and prevent expensive losses to the industry.

Recreation

The mountainous western portion of the basin combines such desirable qualities as scenic attractiveness, wilderness character, remoteness, water for fishing, and skiing facilities. Consequently it is an important recreational area for all seasons. Fishing is a summer sport of considerable financial significance in the permanent bodies of water and especially in the headwater streams. The upper Arkansas River, however, is not particularly suited for fishing because it is laden with mine tailings sediment and polluted with acid mine drainage from the California Gulch runoff.

Existing reservoirs at Twin Lakes and Turquoise between Leadville and Buena Vista provide recreation opportunities for the immediate region. Twin Lakes is developed as a small fishing resort and it is estimated that approximately 8,000 to 9,000 visitor days annually are spent there. Of this number 6,600 are fisherman days. Turquoise Lake is used mostly by summer home occupants. Of its total use, about 600 visitor days annually are devoted to fishing. Clear Creek Reservoir just north of Buena Vista is also used extensively for fishing, an estimated 2,600 fisherman days are spent there annually.

The lower portion of the basin, which stretches over the Great Plains from Pueblo to the Colorado-Kansas State line, has relatively little value from a recreational standpoint. There are several existing reservoirs in this region, but in general they are not suitable for recreational purposes because of wide fluctuations of pool levels and salinity of the waters. The streams in the lower basin are generally intermittent and carry heavy silt loads. They are generally unproductive of game fish.

There appears to be a need for developed recreational areas associated with water activities in the plains region particularly from Pueblo eastward as such opportunities are limited at the present time. Residents of this area now have to travel to the mountains for suitable recreation.

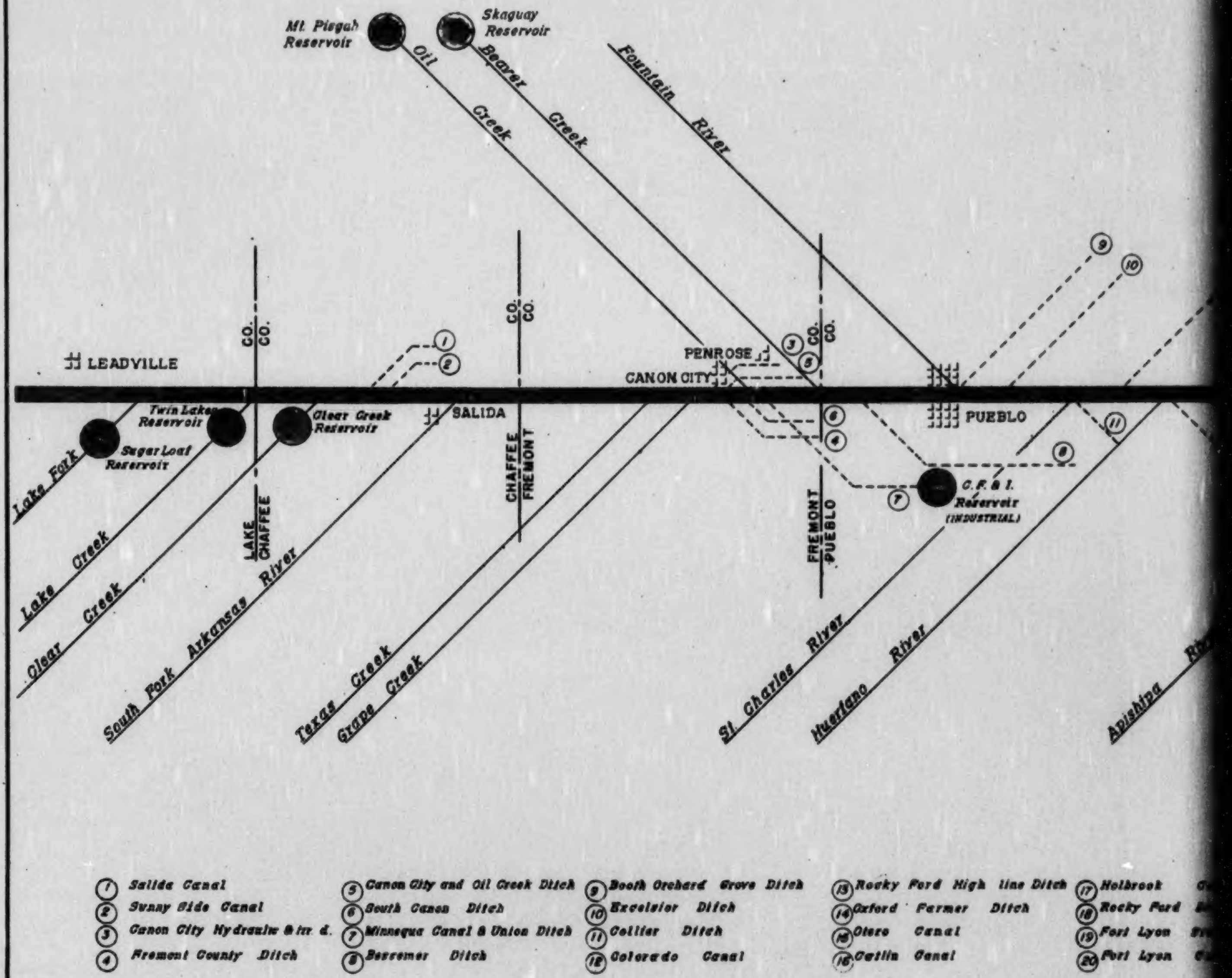
Pollution control is an important part of any recreational development program in the region. The pollution abatement problem is aggravated below Pueblo because of the meager stream flows resulting from high consumption at successive points along the river to the Colorado-Kansas State line.

Fish and Wildlife

Within the Upper Arkansas River Basin there is one Federal hatchery located near Leadville. The waters for operating this hatchery are obtained by diversion from South Rock Creek, a small sub-tributary of the Arkansas River. In addition, there are five fish hatcheries or rearing stations located on various watercourses throughout the basin which are operated by the Colorado Game and Fish Department.

There are also two waterfowl refuges in the basin operated by the Colorado Game and Fish Department. These are dependent upon the surface waters of Two Buttes Reservoir located on Two Buttes Creek near the Colorado-Kansas line, and the John Martin Reservoir located on the main stem of the Arkansas River east of Fort Lyons. Pollution reaching the Two Buttes Reservoir is a minor problem but John Martin Reservoir is the recipient of all municipal, industrial, and silt pollution contributed to the surface waters by sources upstream.

Where pollution does not prevent, the Arkansas River and its tributaries and prairie reservoirs are extensively utilized as resting areas by waterfowl. On the average, about 500,000 ducks and at least 20,000 geese winter in the valley east of Rocky Ford. Hunting pressure is quite heavy, especially on geese in the vicinity of Two Buttes Reservoir and Eads Lakes.


Mt. Pisgah Reservoir
Skaguay Reservoir
Oil Creek
Beaver Creek
Fountain River
LEADVILLE
CO.
CO.
PENROSE
CANON CITY
PUEBLO
SALIDA
Twin Lakes Reservoir
Clear Creek Reservoir
Sugar Loaf Reservoir
C.F. & I. Reservoir (INDUSTRIAL)
LAKE
CHAFFEE
CHAFFEE
FREMONT
FREMONT
PUEBLO
Lake Fork
Lake Creek
Clear Creek
South Fork Arkansas River
Texas Creek
Grape Creek
St. Charles River
Huerfano River
Apishipa
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① Salida Canal
② Sunny Side Canal
③ Canon City Hydraulic & Irr. d.
④ Fremont County Ditch
⑤ Canon City and Oil Creek Ditch
⑥ South Canon Ditch
⑦ Minnequa Canal & Union Ditch
⑧ Bessemer Ditch
⑨ Booth Orchard Grove Ditch
⑩ Excelsior Ditch
⑪ Collier Ditch
⑫ Colorado Canal
⑬ Rocky Ford High line Ditch
⑭ Oxford Farmer Ditch
⑮ Otero Canal
⑯ Catlin Canal
⑰ Holbrook
⑱ Rocky Ford
⑲ Fort Lyon
⑳ Fort Lyon

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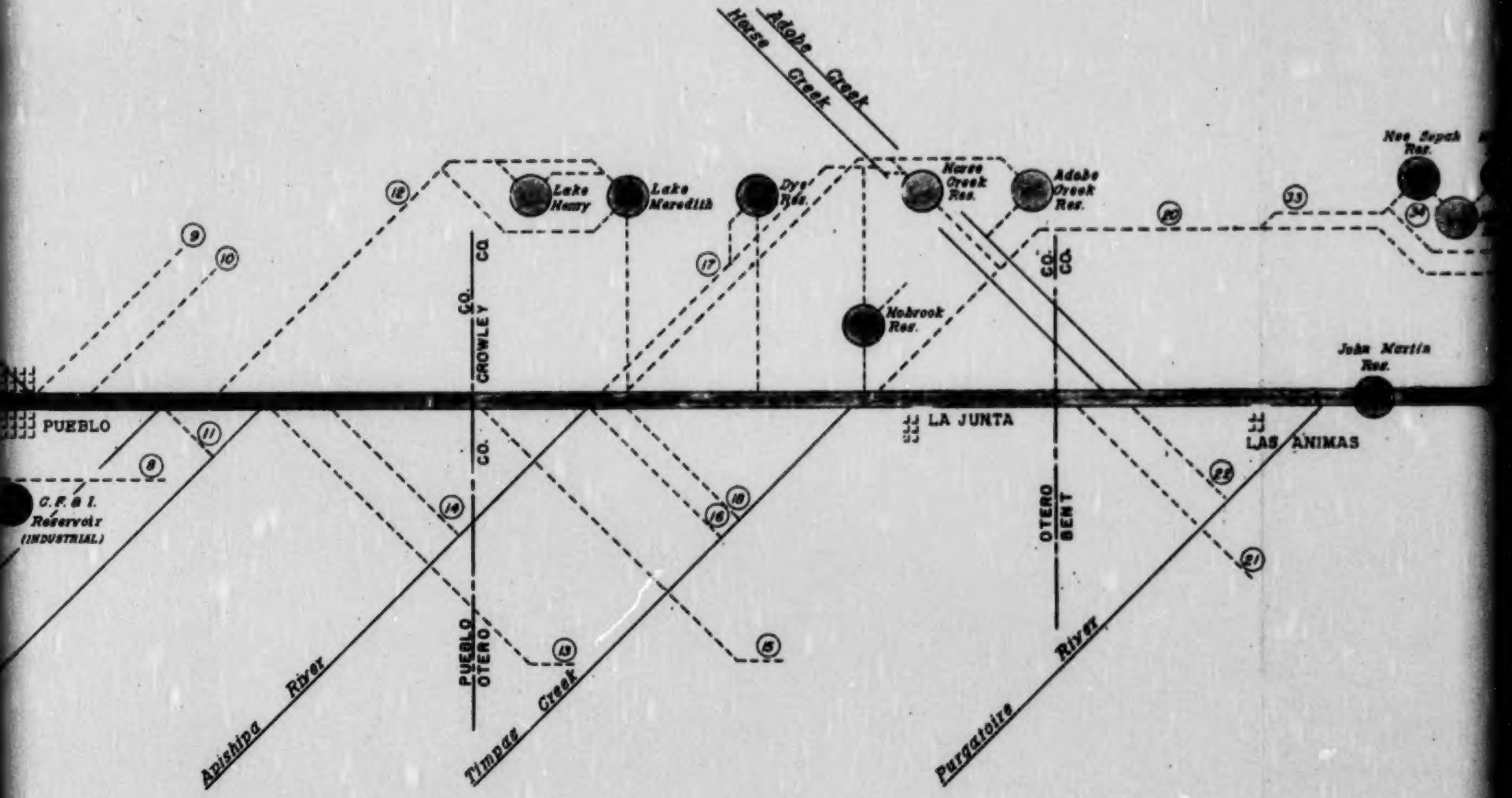
Adobe Creek
Horse Creek
Lake Henry
Lake Meredith
Dye Res.
Horse Creek Res.
Adobe Creek Res.
Nee Sopah Res.
Holbrook Res.
John Martin Res.
PUEBLO
LA JUNTA
LAS ANIMAS
C.F. & I. Reservoir (INDUSTRIAL)
CROWLEY CO.
CO.
PUEBLO
OTERO
OTERO
BENT
CO.
CO.
Apishipa River
Timpas Creek
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⑰ Holbrook Canal
⑱ Rocky Ford Ditch
⑲ Fort Lyon Storage Canal
⑳ Fort Lyon Canal

㉑ Las Animas consolidated ditch
㉒ Las Animas Town Ditch
㉓ Fort Bent Ditch
㉔ Keesee Ditch

㉕ Amity Canal
㉖ Lamar Canal
㉗ Hyde Ditch
㉘ Manvel Canal

㉙ X-Y Canal
㉚ Buffalo Canal
㉛ Stetson Ditch
㉜ Graham Ditch

㉝ Kicking Bird Canal
㉞ Santana Canal
㉟ Comanche Canal
(36) Pawnee Canal

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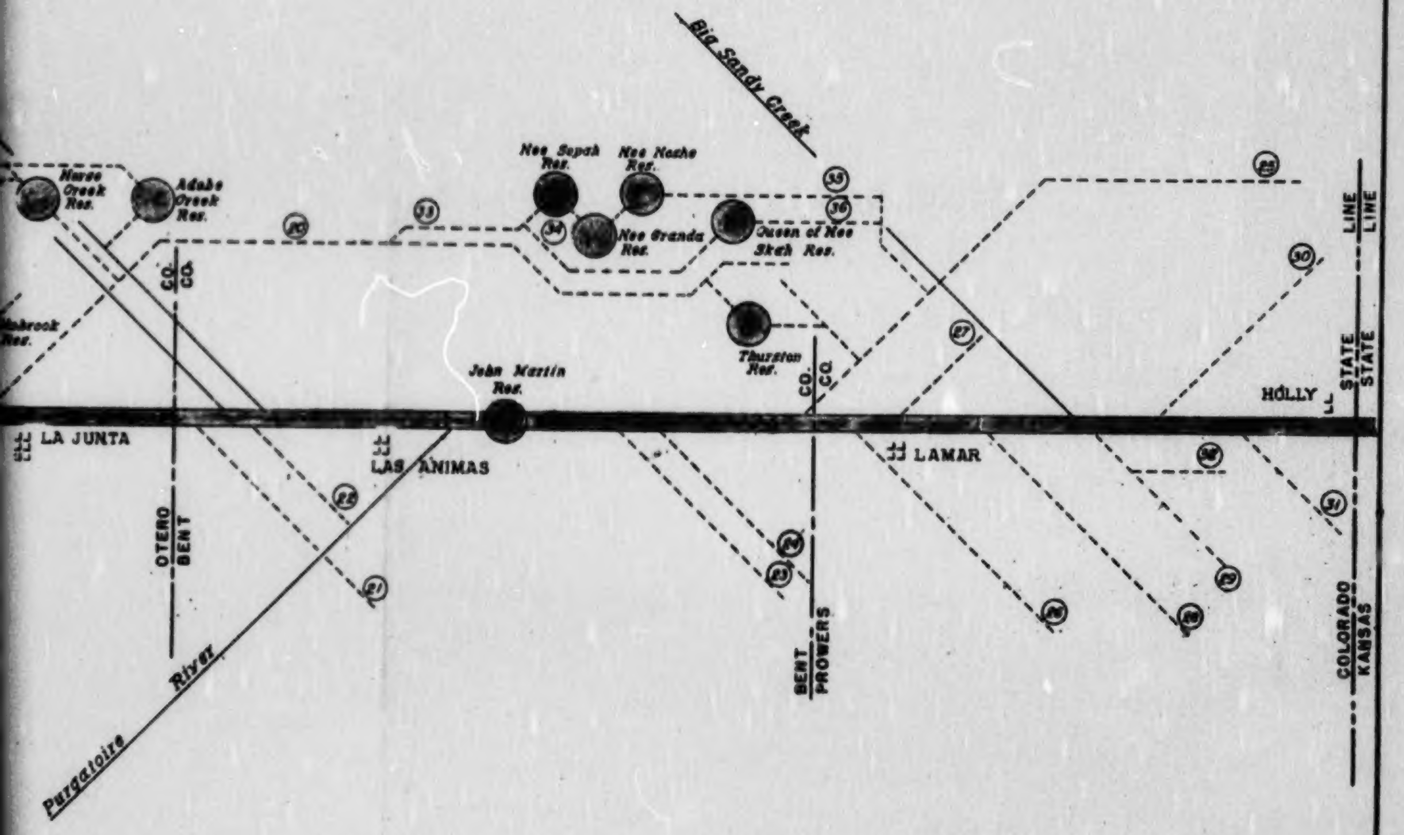
Big Sandy Creek
Horse Creek Res.
Adobe Creek Res.
...hbrook Res.
Nee Sopah Res.
Nee Noshe Res.
Nee Granda Res.
Queen of Nee Skah Res.
Thurston Res.
John Martin Res.
LA JUNTA
LAS ANIMAS
LAMAR
HOLLY
CO. CO.
OTERO BENT
BENT PROWERS
Purgatoire River
STATE LINE
STATE LINE
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㉙ X-Y Canal
㉚ Buffalo Canal
㉛ Sisson Ditch
㉜ Graham Ditch
㉝ Kicking Bird Canal
㉞ Santana Canal
㉟ Comanche Canal
㊱ Pawnee Canal

FIGURE 2

UPPER ARKANSAS RIVER BASIN
above Colorado, Kansas state line

STREAM SYSTEM AND
DIVERSION DIAGRAM

blo, Colorado.

The numbers and distribution of many other game birds and mammals is profoundly affected by surface water conditions in the semiarid high plains area.

Waste Disposal

It is recognized that some portion of the surface waters in the basin must be used for the final disposal of municipal and industrial wastes. The use of watercourses for this purpose, however, is too often exploited and continues uncontrolled at the expense of more important primary water uses. The equitable allocation of waters of a river system should allow for reasonable use for waste disposal, but this use should yield through adequate control to the primary water uses. All water uses will benefit from pollution abatement if the water courses are used judiciously for final disposal of sewage and industrial wastes.

POLLUTION CONTRIBUTED TO WATER RESOURCES

Tables A and B herein, summarize the available information on the extent of pollution originating from municipal and industrial sources which is discharged to the watercourses of the Upper Arkansas River Basin. Maps No. 3 and 4, showing the sources of pollution and existing treatment facilities for municipal and industrial sources, present a pictorial summary of the data on the extent of pollution discharged to the waters of the basin.

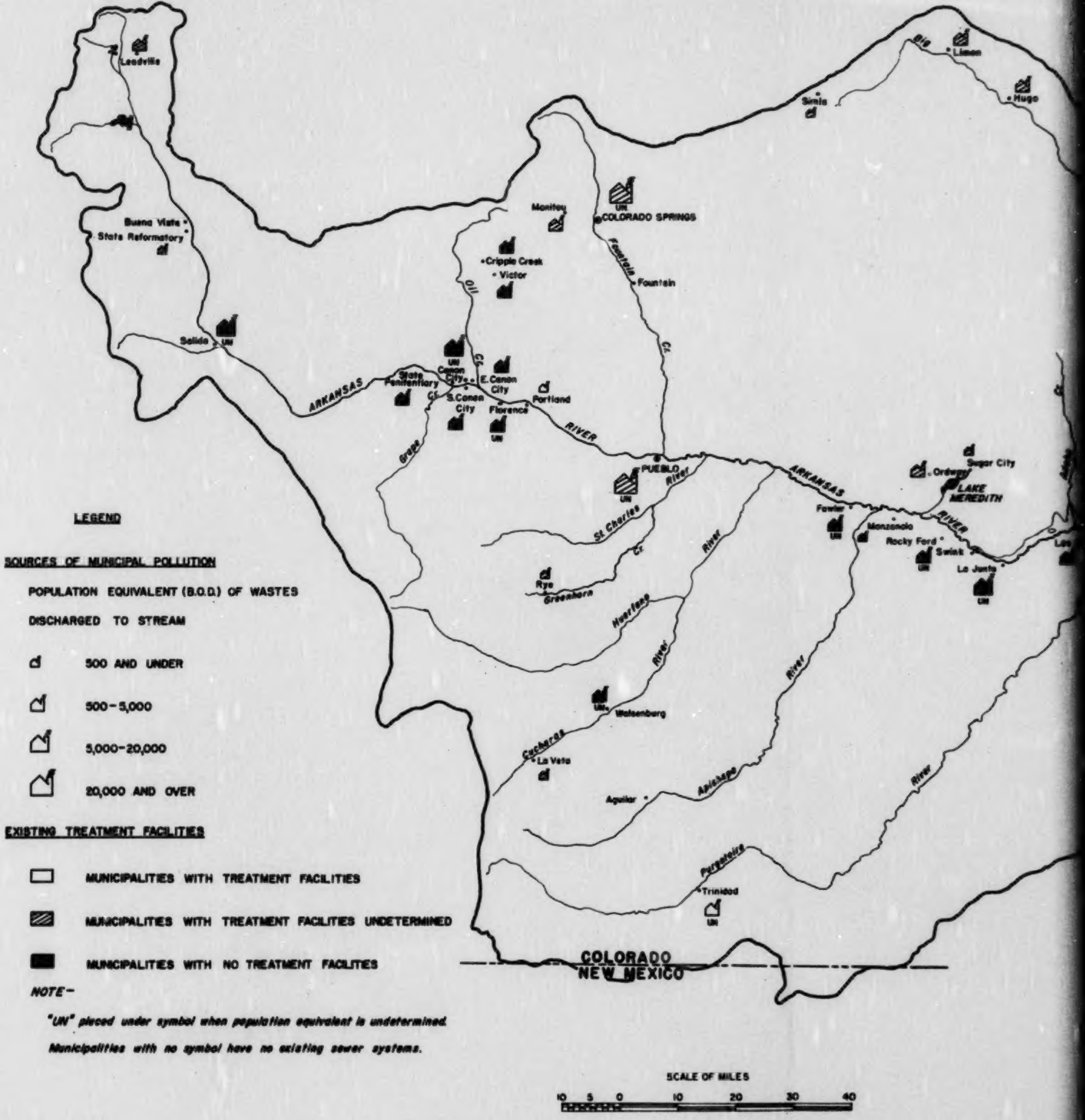
There are 38 sources of municipal pollution within the basin which are considered for purposes of this report. Of this total, two communities, the Colorado State Reformatory (pop. 250) and Wiley (pop. 413), at present, are using subsurface systems for final disposal of sewage effluent. Rye (pop. 160) and Eads (pop, 1,011) dispose of their sewage effluent to open fields. Four other communities, including Aguilar (pop. 1,044), Buena Vista (pop. 776), Fountain (pop. 711), and Swink (pop. 330) have no existing sewer systems, but the need for public sewers and treatment plants in these towns is recognized and facilities are recommended by the Colorado Department of Public Health. Because the eight communities listed above are regarded as potential or future sources of pollution, the data relating to their status or project needs have been included in all subsequent tables and discussion. The town of Manitou (formerly Manitou Springs) has been included as a source of pollution although its sewage is conveyed to the primary treatment plant at Colorado Springs.

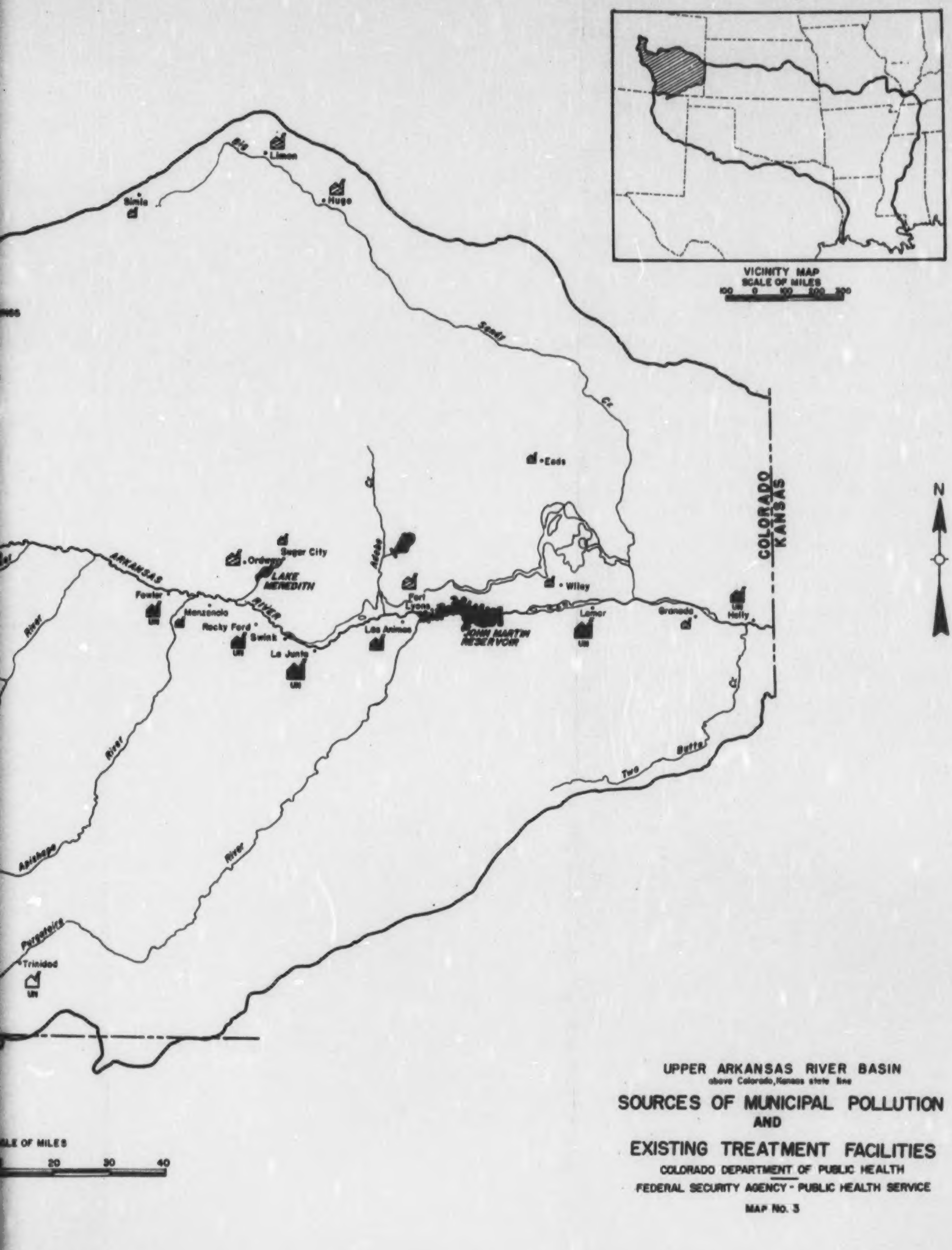
In addition to the 38 sources of pollution being considered in this initial report, there is a group of 20 small communities with a combined population of nearly 5,200 persons which should be considered when developing a future comprehensive water pollution control program for the basin. At present, these 20 communities have individual household disposal systems.

A review and evaluation of the limited data available at present regarding the pollution problems in the basin emphasizes the need for continued effort to secure more complete data on all sources of pollution. Such data should include amount and strength of wastes, present status of treatment facilities, corrective measures required, and other pertinent information necessary to completely define the problems and to institute a reasonable program for the prevention and abatement of pollution.

Table A shows that an estimate of the amount of pollution, represented in terms of equivalent number of people (population equivalent), is available for only 21 municipalities of the 38 sources being considered. The pollution load originating from these 21 municipalities, with a sewered population of 17,300, has a population equivalent of 13,500. The net reduction in pollution load by treatment originating from the sources in this group amounts to about 20%. The amount of pollution originating from the remaining 17 municipalities with a combined sewered population of 154,500 is undetermined.

The lack of data regarding the types and amounts of industrial wastes discharged to the municipal sewerage systems in the latter group of municipalities precludes an estimate of the pollution load reaching the watercourses. However, it is known that industrial wastes discharged to municipal sewers of these communities impose a considerable additional load above that originating from the sewered population.


Leadville
Buena Vista
State Reformatory
Salida
UN
Monitou
UN
COLORADO SPRINGS
Cripple Creek
Victor
Fountain
Oil
Ck.
Fountain
Ck.
UN
Canon City
State Penitentiary
E. Canon City
S. Canon City
Florence
UN
Portland
Ck.
Grape
ARKANSAS
RIVER
PUEBLO
UN
River
St Charles
Ck.
Rye
Greenhorn
Huerfano
River
UN
Walsenburg
Cucharas
River
La Veta
Aguilar
Apishapa
River
Purgatoire
Trinidad
UN
River
Big
Limon
Hugo
Simla
Sugar City
Ordway
LAKE MEREDITH
ARKANSAS
RIVER
Fowler
UN
Manzanola
Rocky Ford
Swink
UN
La Junta
UN
Ck.
COLORADO
NEW MEXICO
LEGEND
SOURCES OF MUNICIPAL POLLUTION
POPULATION EQUIVALENT (B.O.D.) OF WASTES DISCHARGED TO STREAM
500 AND UNDER
500-5,000
5,000-20,000
20,000 AND OVER
EXISTING TREATMENT FACILITIES
▭ MUNICIPALITIES WITH TREATMENT FACILITIES
▨ MUNICIPALITIES WITH TREATMENT FACILITIES UNDETERMINED
■ MUNICIPALITIES WITH NO TREATMENT FACILITIES
NOTE–
"UN" placed under symbol when population equivalent is undetermined.
Municipalities with no symbol have no existing sewer systems.
SCALE OF MILES
10 5 0 10 20 30 40

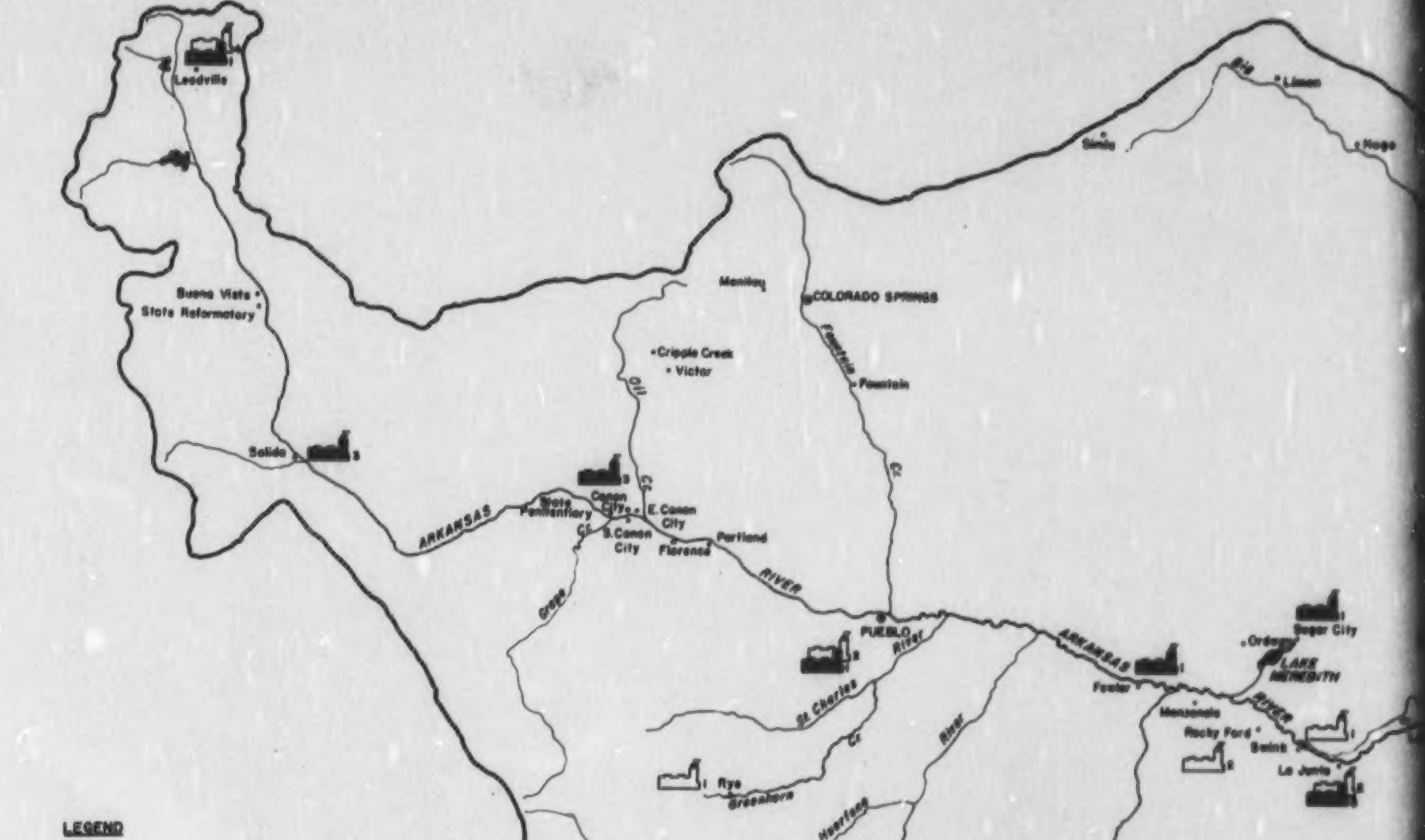

VICINITY MAP
SCALE OF MILES
100 0 100 200 300
Big
Limon
Simla
Hugo
Sandy
Cr.
Eads
Cr.
Adobe
Sugar City
Ordway
LAKE MEREDITH
ARKANSAS
RIVER
Fowler
Un
Manzanola
Rocky Ford
Swink
La Junta
Un
Fort Lyons
Las Animas
JOHN MARTIN RESERVOIR
Wiley
Lamar
Un
Granada
Un
Holly
COLORADO
KANSAS
N
Cr.
Two
Butte
River
River
Apishapa
River
Purgatoire
Trinidad
Un
LE OF MILES
20
30
40

UPPER ARKANSAS RIVER BASIN
above Colorado,Kansas state line

SOURCES OF MUNICIPAL POLLUTION
AND
EXISTING TREATMENT FACILITIES

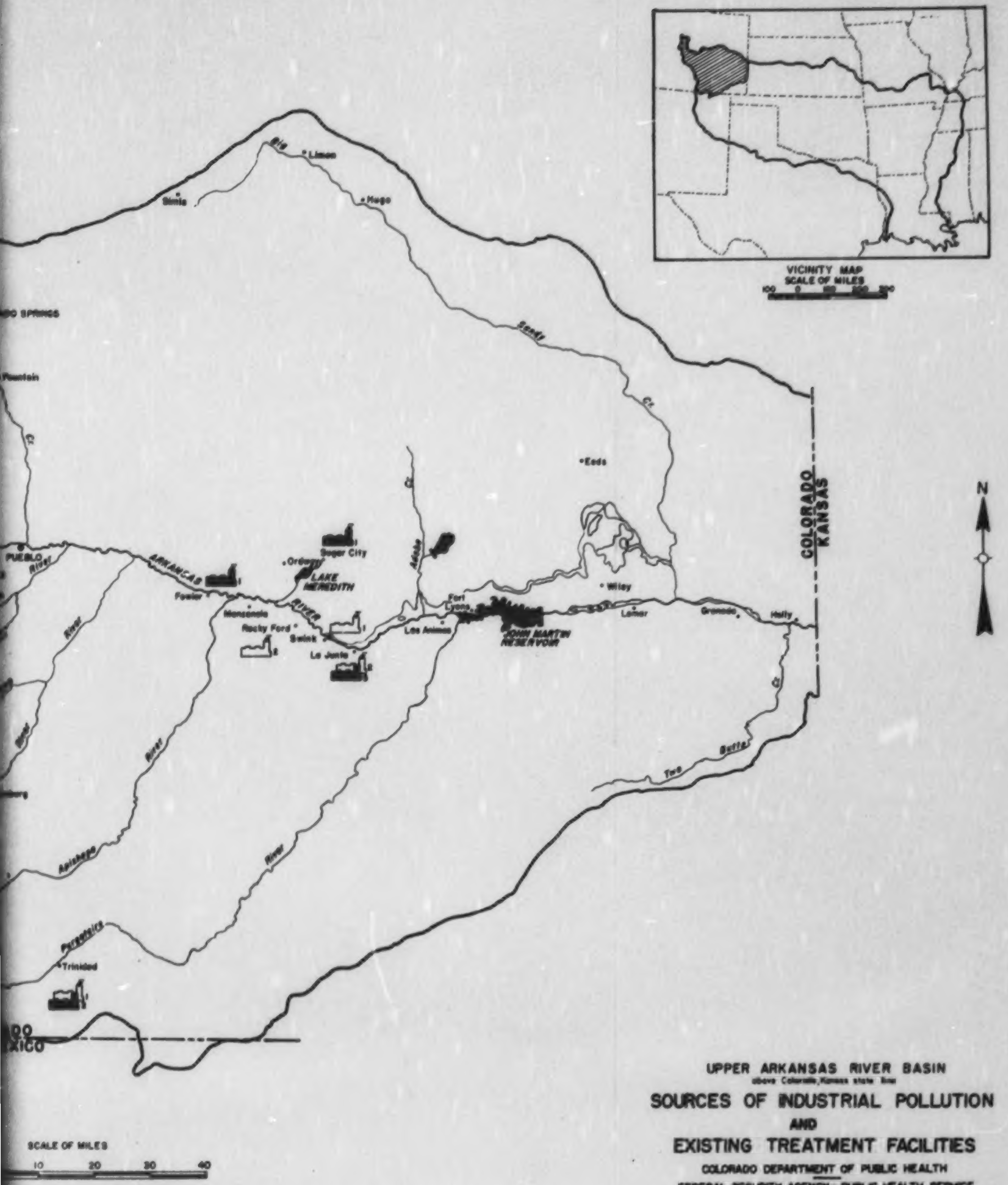
COLORADO DEPARTMENT OF PUBLIC HEALTH
FEDERAL SECURITY AGENCY - PUBLIC HEALTH SERVICE

MAP No. 3


Leadville
Buena Vista
State Reformatory
Salida
ARKANSAS
RIVER
State Penitentiary
Canon City
E. Canon City
S. Canon City
Florence
Portland
Oil Cr.
Grape Cr.
Manitou
COLORADO SPRINGS
Cripple Creek
Victor
Fountain Cr.
Fountain
PUEBLO
St. Charles River
Rye
Greenhorn Cr.
Huerfano River
Cucharas River
Walsenburg
La Veta
Aguilar
Apishapa River
Purgatoire River
Trinidad
Fowler
Manzanola
Rocky Ford
Swink
La Junta
Ordway
Sugar City
LAKE MEREDITH
Big Sandy
Limon
Simla
Hugo
COLORADO
NEW MEXICO
LEGEND
INDUSTRIES WITH TREATMENT FACILITIES
INDUSTRIES WITH NO TREATMENT FACILITIES
INDUSTRIES WITH TREATMENT FACILITIES UNDETERMINED
SCALE OF MILES
10 5 0 10 20 30 40

NOTE—

Numbers appearing by symbols indicate total number of industrial sources of pollution in the area in the category designated.


VICINITY MAP
SCALE OF MILES
100 0 100 200 300
Big
Limon
Simla
Hugo
Sandy
Cr.
Eads
COLORADO
KANSAS
N
DO SPRINGS
Fountain
Cr.
PUEBLO
River
ARKANSAS
RIVER
Fowler
Ordway
Sugar City
LAKE MEREDITH
Adobe
Cr.
Manzanola
Rocky Ford
Swink
La Junta
Las Animas
Fort Lyons
JOHN MARTIN RESERVOIR
Wiley
Lamar
Granada
Holly
Cr.
Two Butte
River
River
Apishapa
River
Purgatoire
Trinidad
ADO
XICO
SCALE OF MILES
10 20 30 40

UPPER ARKANSAS RIVER BASIN
above Colorado-Kansas state line

SOURCES OF INDUSTRIAL POLLUTION
AND
EXISTING TREATMENT FACILITIES

COLORADO DEPARTMENT OF PUBLIC HEALTH
FEDERAL SECURITY AGENCY - PUBLIC HEALTH SERVICE

MAP No. 4

TABLE A

SOURCES OF POLLUTION

MUNICIPAL

Municipalities*	Sources of Pollution (In Number of Municipalities*)	Population Served by Sewerage System	Amount of Pollution Discharged to Watercourse (In Terms of Equivalent number of people)**
Having data on pollution load discharged to watercourse	21 1/	17,300	13,500
Having population data available (Data on pollution load to watercourse incomplete or not available)	17 2/	154,500	Undetermined
TOTAL	38 3/	171,800	xxxxx

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

** Includes industrial wastes discharged into municipal sewerage systems.

1/ Four sources do not reach watercourses, discharge to subsurface disposal systems.

2/ Includes 4 municipalities with no existing sewerage systems - systems recommended by State Department of Public Health.

3/ Manitou included in total - discharges to Colorado Springs plant.

TABLE B

SOURCES OF POLLUTION

INDUSTRIAL*

Industries*	Sources of Pollution (In Number of Plants)	Amount of Pollution Discharged to Watercourse (In Terms of Equivalent number of people)
Producing Organic Wastes	-	-
Producing Organic Wastes	25**	Undetermined
Producing Inorganic Wastes	5	Not Applicable
Producing Wastes of Undetermined Type	1	Undetermined
TOTAL	30***	xxxxx

* Industries having separate outlets discharging wastes directly to watercourse.

** Includes 1 plant also producing inorganic wastes.

*** Total adjusted to correct for duplication noted in footnote marked thus, **.

Data regarding sources of pollution originating from industries having separate outlets discharging to watercourses are shown in Table B. There are 30 industries listed in this category within the basin. The general types of industries include food processing plants, beet sugar refineries, a rendering plant, smelters, steel mills, and mining. Data necessary to estimate the amount of pollution reaching the watercourses are not available. It is known, however, that 24 industries produce organic wastes which are discharged with no treatment or only partial treatment; five industries produce inorganic wastes, most of which reaches the streams without any degree of treatment; and one industry produces waste of an undetermined type which is discharged with no treatment. One industry produces both organic and inorganic wastes typical of iron and steel mills.

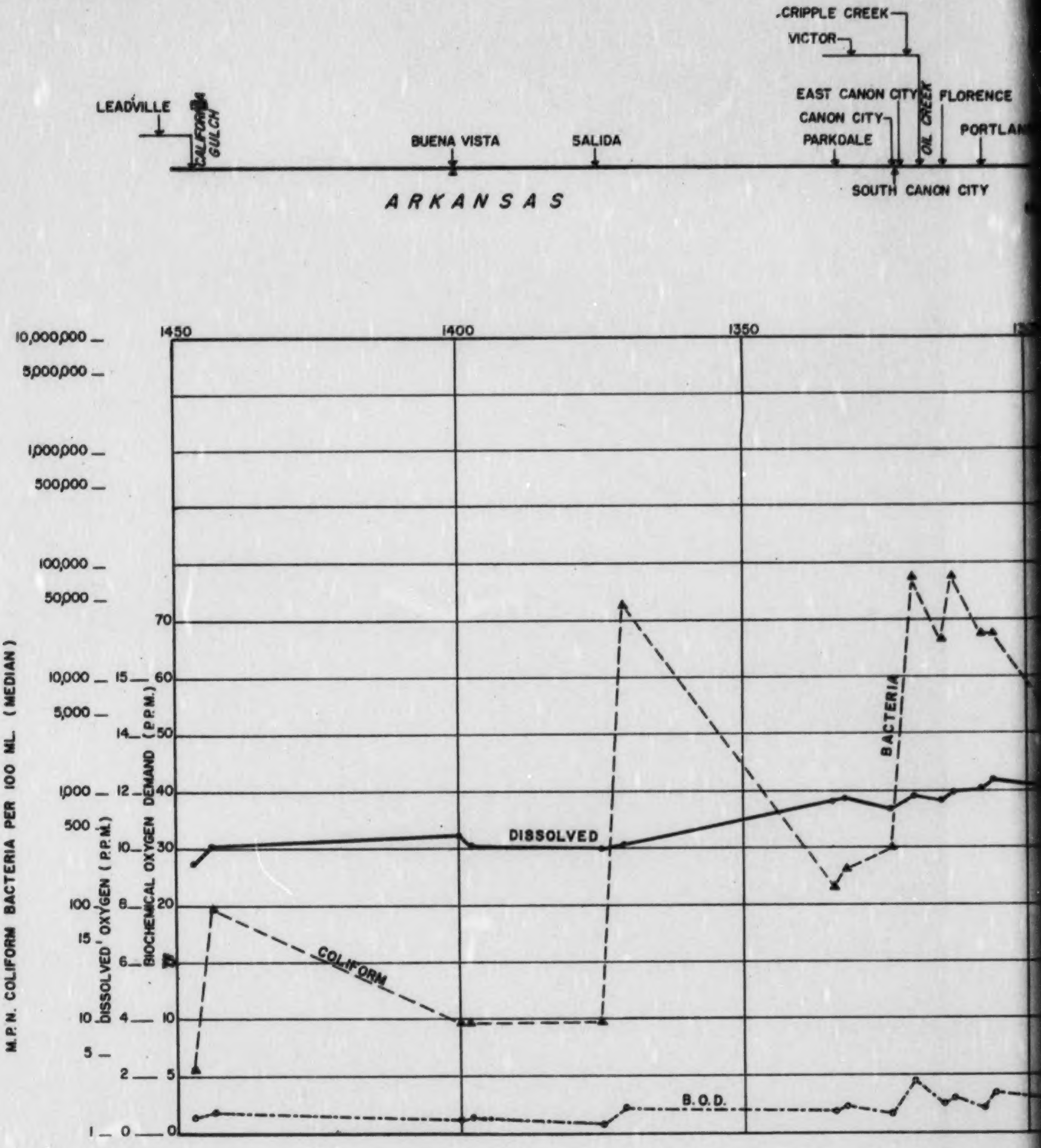
Mine wastes including acid drainage and mine tailings entering the Arkansas River, beginning from California Gulch, are adversely affecting the fish and aquatic life potentials of the river for a considerable distance downstream. There are many old mine tailings retention ponds located along the river which are a continual source of inorganic pollution. The problem is accentuated during flash floods which bring into the river large quantities of silt eroded from the slopes of the abandoned tailings piles.

Additional investigations and studies of all sources of industrial pollution are needed to determine the characteristics and volumes of wastes. Such information is necessary to estimate the pollution load imposed on the receiving waters and also to evaluate the corrective measures required to protect the waters for downstream uses.

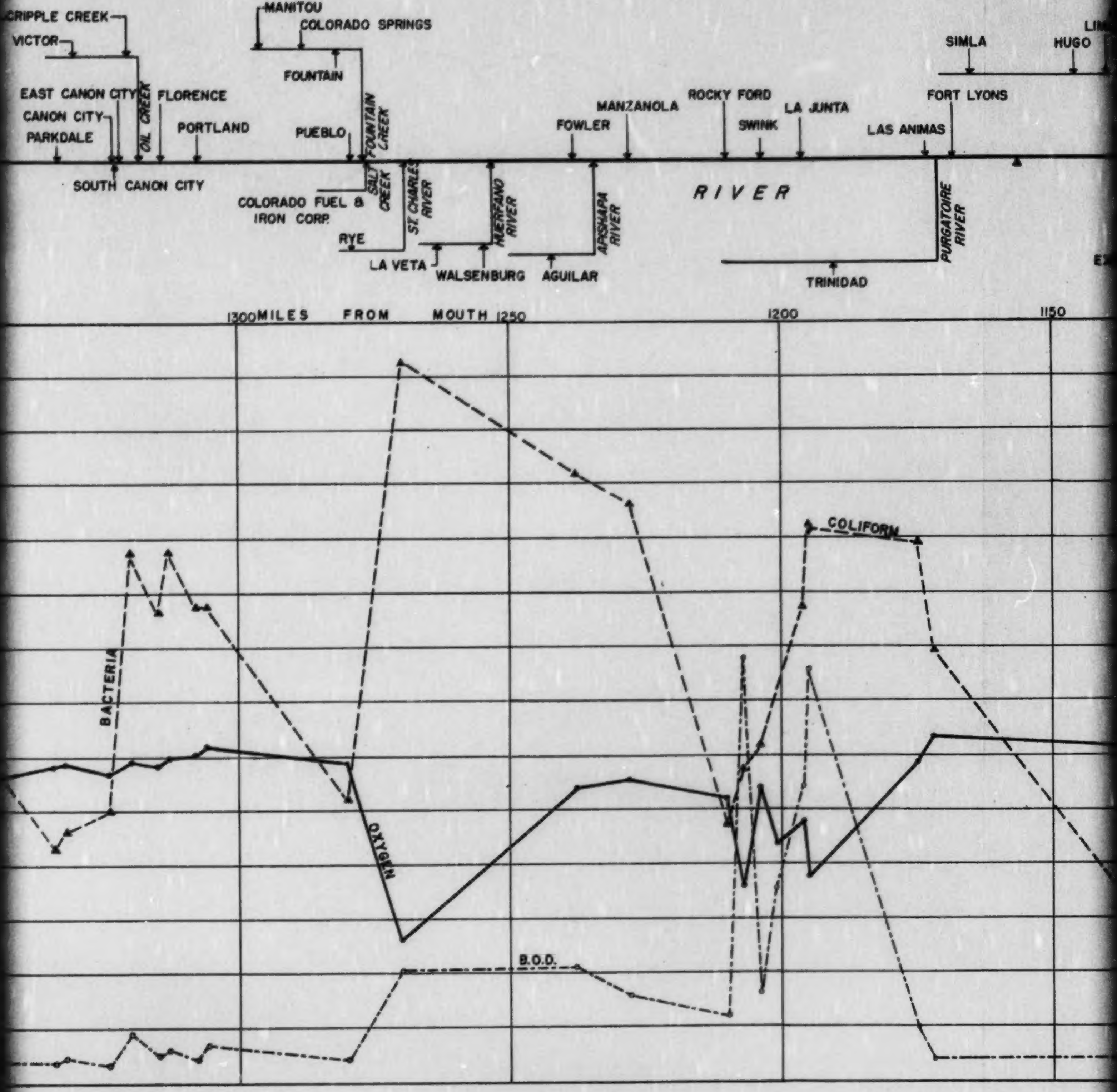
Recognizing this need, the Colorado State Department of Public Health, in cooperation with the Colorado Game & Fish Department made a sanitary survey of the Arkansas River and several of its tributaries during the period October 15, 1950, to January 20, 1951. A series of samples were collected at significant locations along the Arkansas River from Leadville to Holly and on several tributaries including California Gulch, Purgatoire River, Cucharas River, Fountain Creek, and Salt Creek.

A summary of the average laboratory results from all sampling stations is shown in Table 3. Average laboratory results, together with the sources of pollution along the main stem of the Arkansas River, are plotted on Figures 3 and 4. The definitions of laboratory tests and their significance are contained in the appendix under "Water Pollution Investigation of the Upper Arkansas River Basin". Although the data shown represent conditions found during a relatively short period of investigation, they indicate the general trend in water quality along the entire course of the Arkansas River in relation to the major sources of pollution. A progressive deterioration of the river waters from Leadville to Holly is indicated by these data. The pollution contributing to this condition originates primarily from municipal and industrial wastes, and also from natural pollution in the form of silt and high mineral content brought into solution by the runoff passing over the soils and mineral deposits.

A detailed discussion of survey methods employed in the water pollution investigation of the Upper Arkansas River and tributaries together with a summary of individual laboratory results is included in the Appendix.



LEADVILLE
CALIFORNIA GULCH
BUENA VISTA
SALIDA
CRIPPLE CREEK
VICTOR
EAST CANON CITY
CANON CITY
PARKDALE
OIL CREEK
FLORENCE
PORTLAN
SOUTH CANON CITY
ARKANSAS
1450
1400
1350
M.P.N. COLIFORM BACTERIA PER 100 ML. (MEDIAN)
DISSOLVED OXYGEN (P.P.M.)
BIOCHEMICAL OXYGEN DEMAND (P.P.M.)
10,000,000
5,000,000
1,000,000
500,000
100,000
50,000
10,000
5,000
1,000
500
100
50
10
5
1
15
14
12
10
8
6
4
2
0
70
60
50
40
30
20
10
5
0
DISSOLVED
COLIFORM
BACTERIA
B.O.D.


CRIPPLE CREEK
VICTOR
EAST CANON CITY
CANON CITY
PARKDALE
OIL CREEK
FLORENCE
PORTLAND
SOUTH CANON CITY
MANITOU
COLORADO SPRINGS
FOUNTAIN
PUEBLO
FOUNTAIN CREEK
COLORADO FUEL & IRON CORP.
SALT CREEK
ST. CHARLES RIVER
RYE
LA VETA
WALSENBURG
HUERFANO RIVER
AGUILAR
APISHAPA RIVER
FOWLER
MANZANOLA
ROCKY FORD
SWINK
LA JUNTA
RIVER
TRINIDAD
LAS ANIMAS
FORT LYONS
PURGATOIRE RIVER
SIMLA
HUGO
1300
MILES FROM MOUTH
1250
1200
1150
BACTERIA
COLIFORM
OXYGEN
B.O.D.

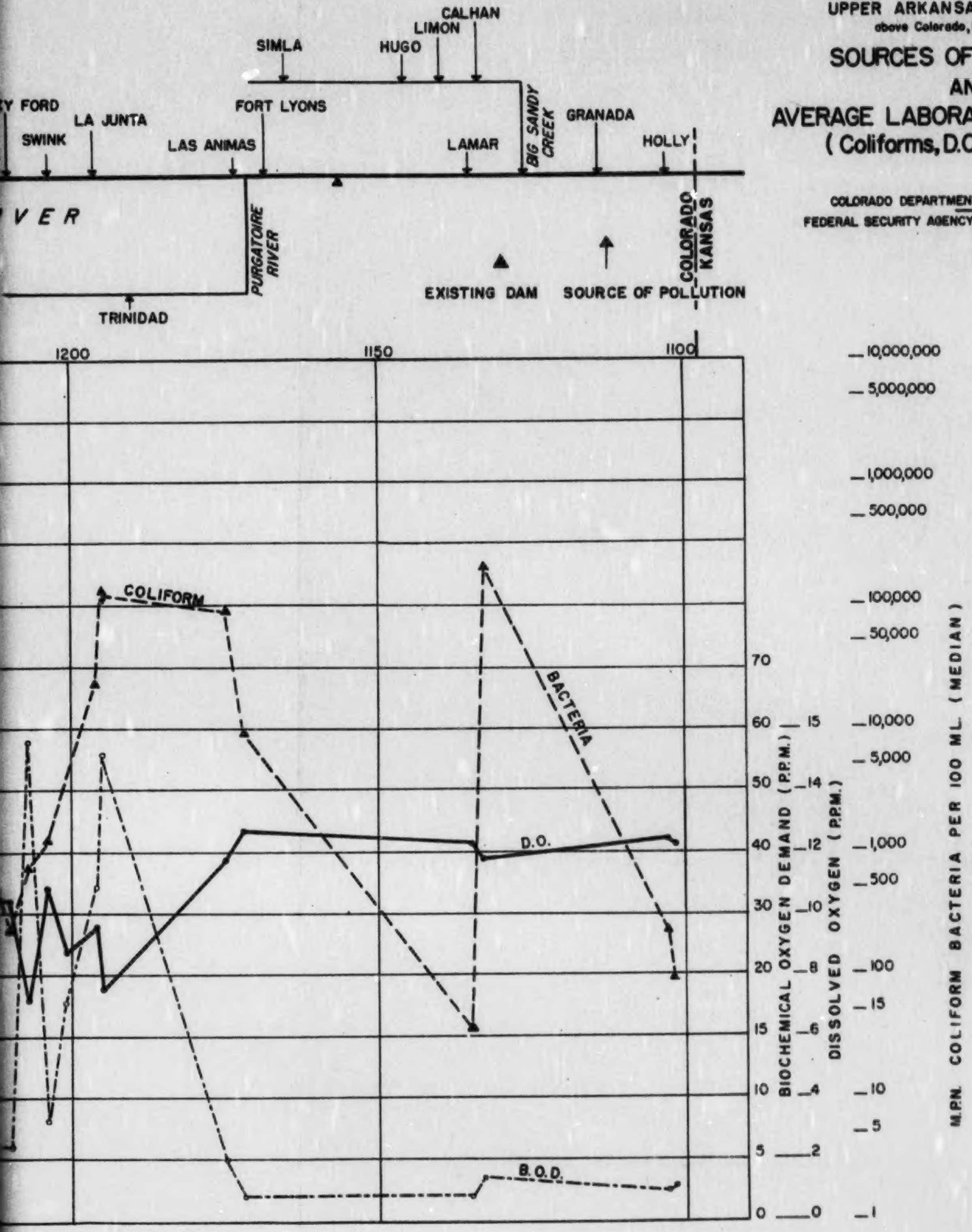
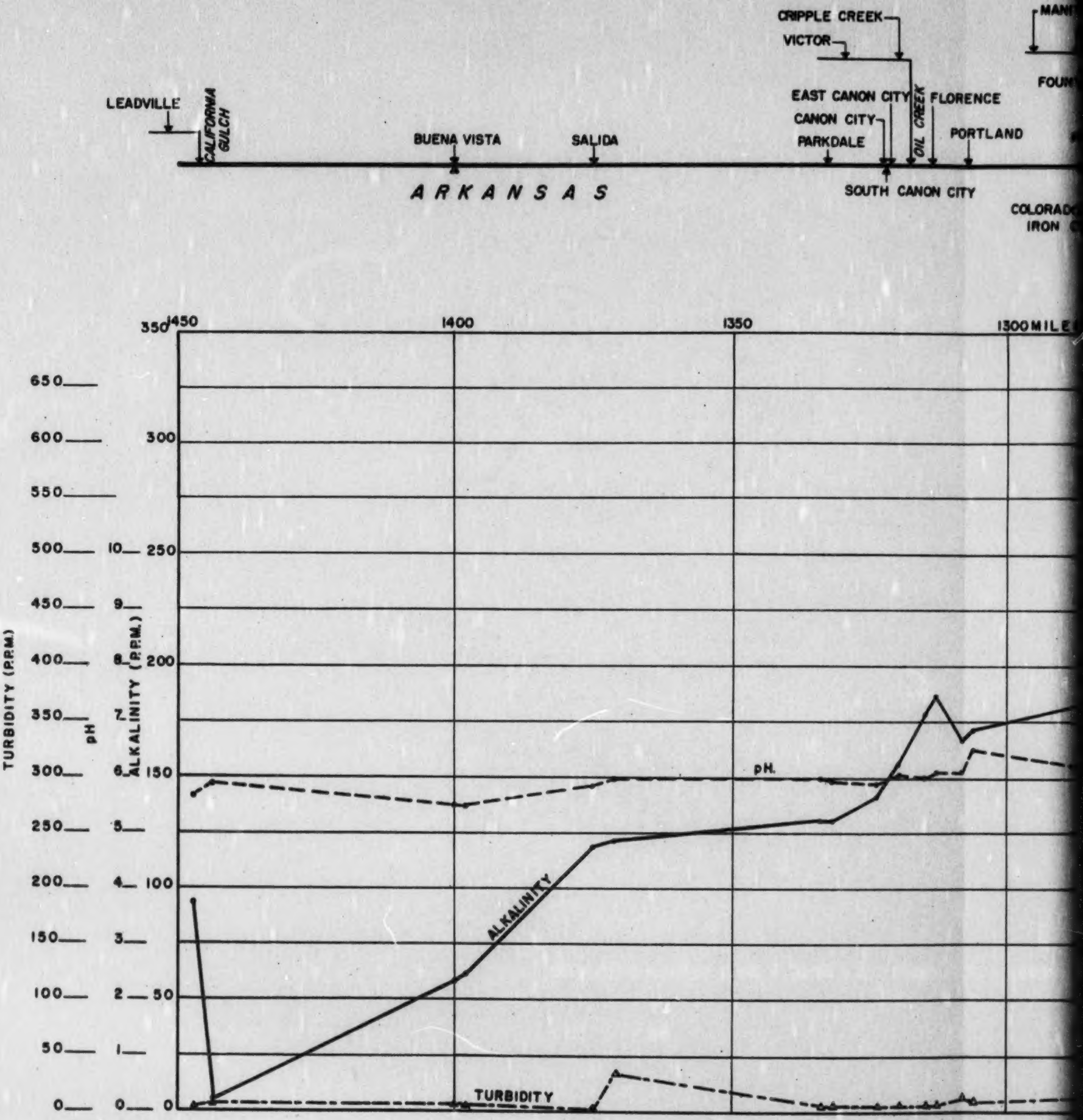


FIGURE 3

UPPER ARKANSAS RIVER BASIN
above Colorado, Kansas state line

SOURCES OF POLLUTION
AND
AVERAGE LABORATORY RESULTS
(Coliforms, D.O. & B.O.D.)

COLORADO DEPARTMENT OF PUBLIC HEALTH
FEDERAL SECURITY AGENCY - PUBLIC HEALTH SERVICE



CRIPPLE CREEK
VICTOR
MANI
FOUN
LEADVILLE
CALIFORNIA GULCH
BUENA VISTA
SALIDA
EAST CANON CITY
CANON CITY
PARKDALE
OIL CREEK
FLORENCE
PORTLAND
SOUTH CANON CITY
ARKANSAS
COLORADO
IRON
1450
1400
1350
1300 MILE
TURBIDITY (P.P.M.)
pH
ALKALINITY (P.P.M.)
650
600
550
500
450
400
350
300
250
200
150
100
50
0
10
9
8
7
6
5
4
3
2
1
0
350
300
250
200
150
100
50
0
pH.
ALKALINITY
TURBIDITY

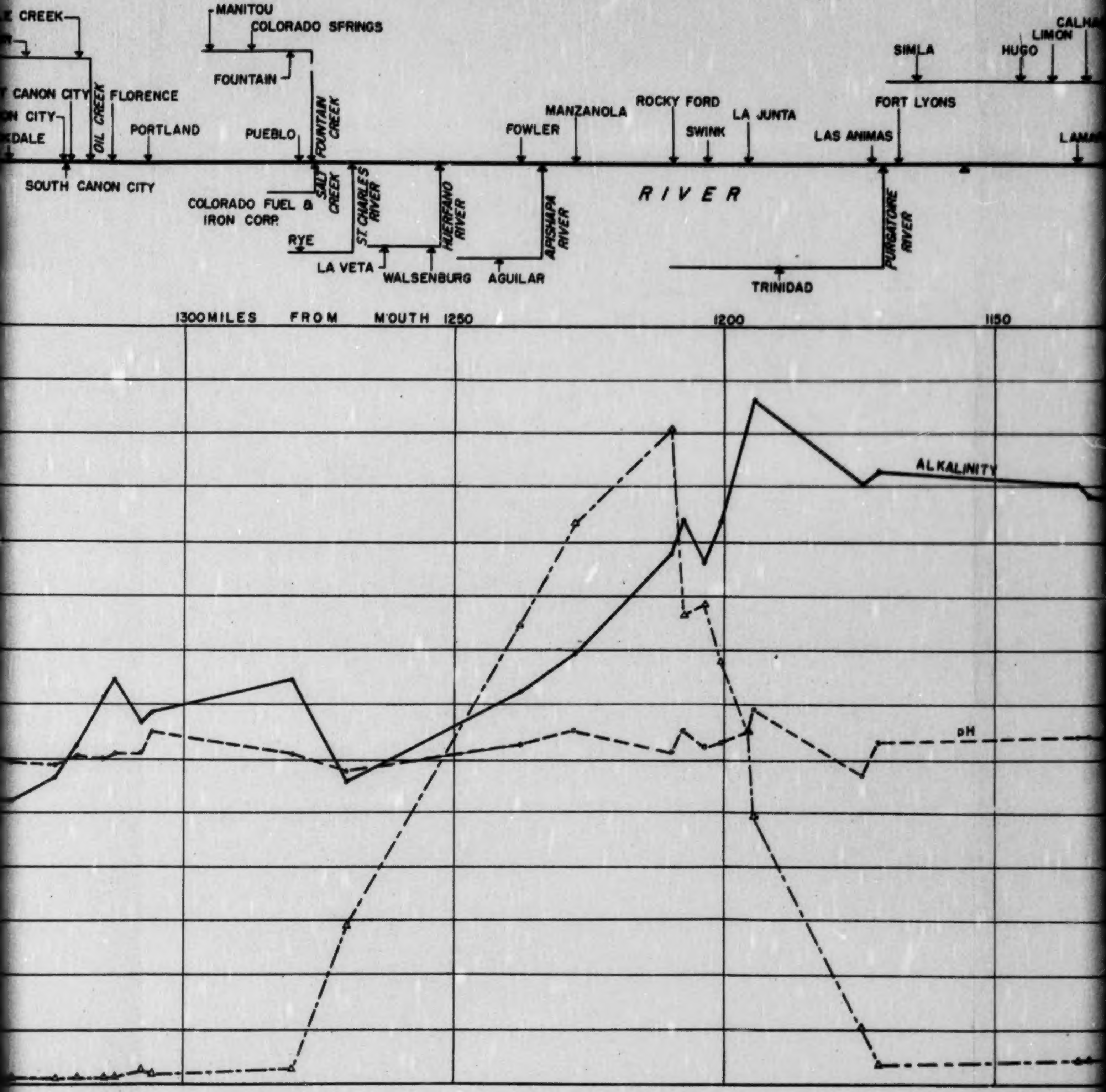

E CREEK
CANON CITY
N CITY
DALE
SOUTH CANON CITY
OIL CREEK
FLORENCE
PORTLAND
MANITOU
COLORADO SPRINGS
FOUNTAIN
PUEBLO
FOUNTAIN CREEK
SALT CREEK
COLORADO FUEL & IRON CORP.
RYE
ST. CHARLES RIVER
LA VETA
WALSENBURG
HUERFANO RIVER
AGUILAR
APISHAPA RIVER
FOWLER
MANZANOLA
ROCKY FORD
SWINK
LA JUNTA
RIVER
TRINIDAD
PURGATOIRE RIVER
LAS ANIMAS
FORT LYONS
SIMLA
HUGO
LIMON
CALHA
LAMA
1300 MILES FROM MOUTH
1250
1200
1150
ALKALINITY
pH

FIGURE 4

UPPER ARKANSAS RIVER BASIN
above Colorado, Kansas state line

SOURCES OF POLLUTION
AND
AVERAGE LABORATORY RESULTS
(Turb., pH, & Alk.)

COLORADO DEPARTMENT OF PUBLIC HEALTH
FEDERAL SECURITY AGENCY - PUBLIC HEALTH SERVICE

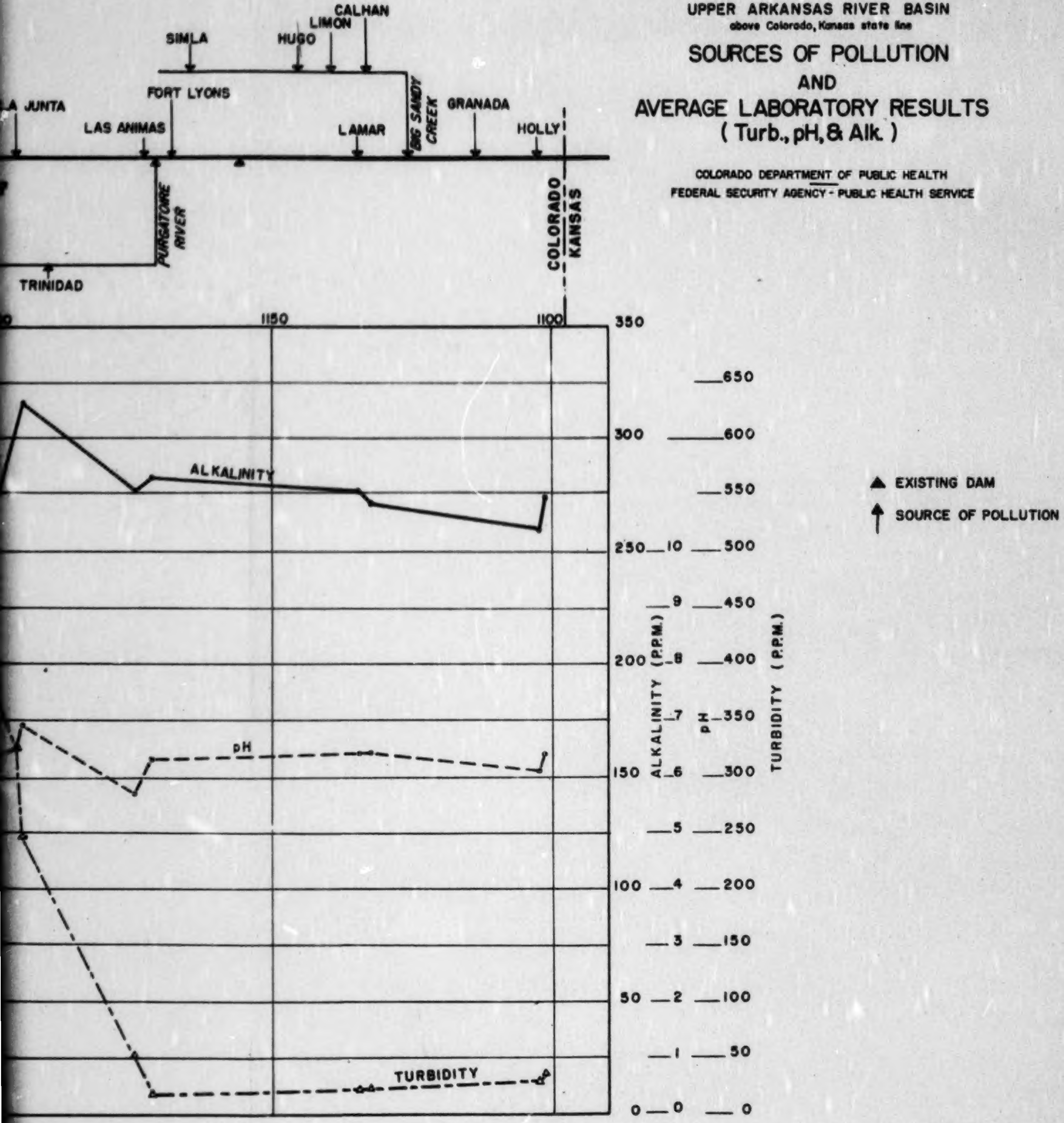


Table 3 - UPPER ARKANSAS RIVER BASIN

SUMMARY OF AVERAGE LABORATORY RESULTS

(Results of Survey by Colorado Dept. of Public Health
Oct. 15, 1950 - Jan. 20, 1951)

Watercourse - Location of Stations	River Miles	Coliforms M.P.N. per 100 ml. (median)	D.O. p.p.m.	B.O.D. p.p.m.	Alk. p.p.m.	Turb. p.p.m.	pH
California Gulch							
100 yds. above Leadville outfall	1450.0	93	5.4	0.3	26	30	4.7
Bridge on Hwy. 24 1 mile below Leadville outfall	1450.0	93,000	7.1	>6.6	29	34	5.4
Arkansas River							
above confluence with Calif. Gulch	1447.0	3.6	9.4	1.3	95	4	5.7
Bridge on Hwy. 24 3½ mi.below Malta	1443.5	93	10.1	1.7	6	8	5.9
Buena Vista old powerhouse dam	1401.0	9.1	10.4	1.0	58	6	5.5
below Buena Vista	1400.0	2,380	10.1	1.1	63	6	5.5
above Salida	1375.0	93	9.9	0.7	119	3	5.9
below Salida	1373.0	43,000	10.1	2.0	122	35	6.0
above Parkdale	1334.3	140	11.6	1.7	132	5	6.0
below Parkdale	1332.0	200	11.7	2.1	131	6	6.0
above Canon City	1324.3	300	11.3	1.5	142	5	5.9
below Canon City	1320.0	75,000	11.8	4.3	156	5	6.1
above Florence	1315.0	21,000	11.6	2.2	177	6	6.0
below Florence	1313.5	75,000	11.9	2.9	187	7	6.1
above Portland	1308.0	23,000	12.0	1.9	167	12	6.1
below Portland	1306.0	23,000	12.3	3.2	172	9	6.5
above Pueblo	1280.0	390	11.7	1.9	187	13	6.1
below Pueblo	1270.0	4,300,000	5.2	10.0	140	145	5.8
above Fowler	1238.0	390,000	10.8	10.4	181	423	6.3

Table 3 (Cont'd)

Watercourse - Location of Stations	River Miles	Coliforms M.P.N. per 100 ml. (median)	D.O. p.p.m.	B.O.D. p.p.m.	Alk. p.p.m.	Turb. p.p.m.	pH
Arkansas River							
above Manzanola	1228.0	210,000	11.2	7.7	198	517	6.5
above Rocky Ford	1210.0	** 2,300,000 230	10.4	** >22.4 5.9	245	604	6.1
below Rocky Ford	1207.0	** 2,300,000 750	7.2	** 330.0 57.4	260	433	6.5
above Swink	1204.0	1,200	10.8	7.9	240	442	6.2
below Swink	1201.0	--	8.7	17.7	259	389	6.3
above LaJunta	1196.5	23,000	9.6	34.0	307	325	6.5
below LaJunta	1195.0	>120,000	7.5	55.3	315	246	6.9
above Las Animas	1175.0	93,000	11.7	4.6	276	52	5.7
below Las Animas	1172.0	9,300	12.7	1.7	283	17	6.3
above Lamar	1135.6	36	12.3	1.7	277	22	6.4
below Lamar	1133.0	210,000	11.8	3.3	272	22	6.4
above Holly	1103.4	230	12.4	2.1	258	29	6.1
below Holly	1102.0	91	12.3	2.5	274	35	6.4
***Meridith Lake outlet**		0	10.7	5.9	198	90	6.2
Purgatoire River							
above Trinidad		0	11.4	0.8	224	18	5.8
below Trinidad		15,000	11.5	5.1	287	20	6.0
Cucharas River							
above La Veta		230	9.6	1.1	311	16	5.9
below La Veta		2,300	12.4	1.8	277	13	5.9
above Walsen Camp		36	10.8	2.3	691	12	6.8
above Walsenburg		430	9.2	1.7	1295	11	7.6
below Walsenburg		>21,000,000	7.0	37.0	532	26	6.6

Table 3 (Cont'd)

Watercourse - Location of Stations	River Miles	Coliforms M.P.N. per 100 ml. (median)	D.O. p.p.m.	B.O.D. p.p.m.	Alk. p.p.m.	Turb. p.p.m.	pH
Fountain Creek							
above Colorado Springs		280	12.0	1.4	170	19	5.5
below Colorado Springs		230	6.7	81.7	166	27	5.8
above Fountain		2,300	10.6	3.4	202	27	5.8
below Fountain		2,300	8.4	4.5	204	22	5.8
Salt Creek							
above Colo. Fuel & Iron Corp.		30	9.3	1.8	194	6	6.5
coke plant, C.F.& I. Corp.		23,000	3.6	>73.0	154	1493	6.6
main outfall C.F.& I. Corp.		39,000	6.7	3.1	147	19	6.3
below C.F.& I. Corp. plant		64,000	4.2	>13.6	151	405	6.6

* Water from Lake Meridith is released to irrigation ditch during irrigating season.

** Taken during sugar beet season.

DAMAGES TO WATER RESOURCES FROM POLLUTION

Damages to water resources from pollution in the Upper Arkansas River Basin may be considered under two general categories, namely, the existing or specific damages and the potential damages which may result from the use of polluted waters. Practically all primary water uses in the basin are affected to some degree by pollution originating from municipal, industrial, and natural sources.

Municipal water supplies obtained from polluted surface waters require more extensive treatment to provide potable water for domestic purposes. Leadville, Canon City, Portland, Pueblo, Rocky Ford and Wiley use the Arkansas River as a source of water supply. With the exception of Leadville, the river water is treated for domestic use, but the methods and facilities are not considered adequate in all cases to process the raw water available. High concentrations of bacteria, taste and odor producing substances, and other deleterious materials which are present in waters used for sources of public supplies, increase the cost of treatment and are an ever present hazard which challenge the delivery of a safe and palatable water for public consumption. Other types of pollution in the form of silt and high mineral content similarly increase the cost of treatment by requiring more chemicals, additional physical facilities and extra operating personnel.

Several of the industries using the Arkansas River as a source of water supply also resort to expensive treatment to render the water suitable for process and boiler feed purposes. In some cases the unsuitable surface waters have forced industries to develop individual supplies from ground water sources at great expense.

Ample water supplies of satisfactory quality are essential for the growth and industrial development of the region. Because of the limited quantities of water available, especially in the plains area below Pueblo, it is imperative that the existing supplies be protected from pollution for optimum use.

The extensive acreage devoted to irrigated farming makes irrigation the principal water use in the basin. One of the main factors which has restricted the further development of irrigated farming is the inadequate supply of water. For this reason, the use of available water for irrigation is made with little consideration of quality. The use of sewage polluted waters, especially for the irrigation of truck crops, presents a potential public health hazard.

Several disease outbreaks have been suspected to be associated with the consumption, in the raw state, of low growing crops irrigated from sewage polluted waters. The important significance of this problem is gaining recognition by health authorities and is the subject of investigations by the Public Health Service and other health groups.

Silt pollution causes considerable damage to irrigation facilities. In some instances long reservoir feeder canals have lost 50 percent of their capacity because of sedimentation. The useful life of impoundments constructed for the conservation of water for irrigation purposes has been reduced appreciably by sedimentation and large amounts of undesirable sediment and minerals which have deposited on and caused damage to irrigated lands.

Possible hazards to livestock, particularly dairy cattle, must receive consideration. The loss of livestock resulting from the use of polluted streams and irrigation canals for watering purposes presents a potential economic loss in this region dependent upon livestock raising for a large part of its economy.

Fishing is one of the principal recreational attractions and has considerable financial significance in the upper Arkansas Valley. Damage to this important water use from pollution, especially along the main stem of the Arkansas River, also deserves important consideration. Damage to fish and other aquatic life results from three main types of pollution. (1) Organic pollution, originating mostly from domestic sewage and food processing industries, reduces or depletes the oxygen content necessary for the support of fish life in the streams. (2) Toxic materials, acids, and other inorganic wastes destroy fish or create an environment unsuitable for the production of water life used as fish food. (3) Sediment deposited in the watercourses covers plant and animal life used as sources of fish food and also destroys the natural spawning areas.

Sediment eroded from mine tailings piles along the upper Arkansas River below Leadville is rendering the otherwise potential trout waters unproductive for many miles downstream. The waters of the Arkansas River in the plains region are unproductive of game fish on account of the dissolved salts and high mineral content. The development of other water recreational activities has also been hampered by the unsuitable quality of the waters. Inhabitants of the plains region are forced to travel hundreds of miles to the mountains in search of suitable recreational opportunities.

BENEFITS RESULTING FROM POLLUTION PREVENTION AND ABATEMENT

In a consideration of benefits resulting from pollution prevention and abatement, it can be stated generally that all legitimate water uses enjoy some degree of benefit, either directly or indirectly, from a program of pollution control. In a broader sense, the benefits may be applied to the conservation and development of our fundamental human, land, and water resources. In some cases the benefits can be evaluated on a monetary basis and are considered as tangible benefits. In this category are included principally the benefits accruing from reduced costs for municipal and industrial water treatment. Most generally prevailing, however, are the intangible benefits to public health, recreation, aquatic life, and purely aesthetic considerations, which are equally real and justified, but because of their nature cannot readily be assigned a specific or monetary value.

Several communities in the basin using surface waters as a source of public supply, will be confronted with critical water shortages if there is an increase in the demand from population growth or industrial development. Protecting the available waters from pollution to permit their optimum use and reuse will extend the time for needed additional supplies. In some cases the need may be alleviated. Pollution abatement will also permit municipal water treatment plants now treating polluted waters to operate with a greater factor of safety from a public health standpoint and at less cost.

Manufacturing enterprises have been slow to develop in the basin despite the prevalence of raw materials. In general, a better quality water is required for industrial use than is presently available in many areas of the basin. Any beneficial change in the quality of water available for industrial use will decrease the high cost of treatment and thereby serve as a direct financial benefit and inducement to industrial expansion and development. Other direct benefits to industry often result from waste recovery measures. It has been demonstrated in numerous instances that industrial waste treatment often results in the conservation of valuable resources through reuse of raw materials or salvage of by-products. The return from the reuse or sale of recovered material is in many cases a direct financial benefit to the industry or contributes to the cost of installation and operation of waste treatment facilities.

The use of surface waters for irrigation is the major water use in the basin and is considered one of the principal problems related to water pollution. The public health hazards associated with the use of sewage polluted waters will be decreased by the use of waters which are rendered free of harmful bacteria by the adequate treatment of domestic sewage. The control of silt and harmful mineral pollution will decrease the cost of maintaining irrigation facilities and will promote better crop production. Livestock losses resulting from the use of polluted waters for watering purposes can be prevented and the high costs incident to the settlement of damage claims can be avoided through pollution prevention and abatement measures.

Benefits to the important fish resources of the basin would result primarily in the reach of the Arkansas River from Leadville to Canon City.

The control of sediment originating from mine tailings deposited along the banks and control of acid mine drainage entering the stream will restore many miles of the river which are otherwise suitable for the propagation of game fish. The development of fish and wild life resources in the river below Pueblo has been hampered mainly by the intermittent character of the stream flows and unfavorable mineral quality of the water. Benefits to those resources in the lower reach of the river will result primarily from the importation of additional water to this area as proposed in the Fryingpan-Arkansas Project.

In addition to increasing the recreational opportunities by developing the fish resources of the streams in the basin, the improvement of the aesthetic qualities of waters offers added inducement to vacationers and others seeking relief in the "open spaces" offered by the natural scenic resources of the region.

POLLUTION PREVENTION MEASURES IN EFFECT

Some progress in providing pollution prevention measures for the protection of the watercourses within the basin is evidenced by the data available. The effectiveness of these measures as a whole, however, has been inadequate and as a result pollution from the many sources has degraded the waters to a condition causing concern of many public agencies and private interests. Too often, waste treatment plants or other pollution abatement facilities are provided to alleviate some immediate local condition. The projects are conceived with little or no thought of integration with a broad program of water pollution control designed to protect or benefit all interests utilizing the water resources of a river system.

Data available on existing municipal waste treatment plants are shown in Table C. Only 18 of the 38 municipalities listed as sources of pollution provide some degree of treatment for their wastes. Sixteen municipalities are served by primary treatment plants and 2 municipalities are served by secondary treatment plants. Twenty municipalities including 4 without existing sewerage systems have no treatment facilities for their wastes. Primary plants serve 116,500 persons or 68 percent of the total sewered population in the basin, 7,400 persons or 4 percent are served by secondary plants, and 47,900 persons or 28 percent of the population are not connected to sewers or served by waste treatment facilities. The primary plant at Colorado Springs also serves the town of Manitou.

Table D shows a summary of the data regarding existing industrial waste treatment facilities. There are 30 industries listed as sources of pollution discharging wastes directly to watercourses. The large number of industries discharging wastes to municipal sewerage systems are not included in the tabulation. The effect of the wastes produced by these industries upon the watercourses has been considered, to the extent known, in the summary of sources of municipal pollution (Table 1a).

It should be noted that 23 industries produce organic wastes associated with the processing of food and kindred products. Of this number 12 industries have treatment facilities and 11 discharge wastes without treatment. One rendering plant also producing organic wastes has no treatment facilities.

There are 5 industries producing inorganic wastes associated with mining and processing of metals, 4 of which provide no facilities for control or abatement of their wastes. One railroad maintenance shop similarly, does not have any type of facility for treating its wastes.

The number of existing municipal and industrial waste treatment facilities in the basin does not necessarily represent a measure of the pollution abated from the watercourses. As stated previously, too often waste treatment plants or other facilities are provided to alleviate some local condition. In due time many plants become obsolete and inadequate for reasons of insufficient capacity, poor maintenance or neglected operation and their usefulness is decreased or entirely lost. The effectiveness of any type of facility is measured by its net result in accomplishing re-

TABLE C

EXISTING TREATMENT FACILITIES

MUNICIPAL

Degree of Treatment Provided	Number of Municipalities* Served	Number of Treatment Plants	Population Served
Primary	16 [1]	15	116,500
Secondary	2	2	7,400
No Treatment	20 [2]	-	47,900

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

[1] Manitou sewage treated in Colorado Springs plant.

[2] Includes 4 municipalities with no existing sewerage systems.

TABLE D

EXISTING TREATMENT FACILITIES

INDUSTRIAL *

Type Industry (**)	Number of Plants	Number of Industrial Plants Having:		
		Treatment Facilities	No Treatment Facilities	Undetermined Facilities
Food & Kindred Products	23	12	11	0
Rendering	1	0	1	0
Primary Metals Industries	2	0	2	0
Mine Drainage	1	1	0	0
Other Mining Industries	2	0	2	0
Railroad Shops	1	0	1	0

* Industries having separate outlets discharging wastes directly to watercourse.

duction of pollution discharged to a receiving watercourse.

The status as to the adequacy of the existing municipal and industrial facilities in the basin is shown in Tables E and F. Only 8 or about one half of the existing municipal treatment plants are adequate as to capacity, 5 are inadequate, and status of 4 is undetermined. Of the 13 existing industrial waste treatment facilities, 4 are inadequate, and the status of the remaining 9 is undetermined.

The information regarding the operation of the municipal and industrial waste treatment plants and other facilities is not complete for a full evaluation of the conditions existing, but the available data indicates there remains much to be desired. Only 5, or about one third, of the existing municipal treatment plants have satisfactory operation, 3 have unsatisfactory operation, and the quality of operation of the remaining 9 plants is undetermined. The operation of the industrial treatment facilities is even inferior to that of the municipal plants. Of the 13 industrial facilities, the operation of 4 is considered unsatisfactory, and the operation of the remaining 9 facilities is undetermined.

Relatively little progress has been made to abate pollution in the basin as measured by the construction of pollution abatement facilities. Table G shows that only 3 municipal treatment plants were constructed in the basin during the last five year period (1946-1950). One plant was built in 1947 to serve 730 persons and 2 plants were built in 1950 to serve a combined population of 2000. During the same period, no industrial waste treatment plants were completed.

The administrative efforts of the State to promote pollution abatement have been handicapped for a number of years. This situation is reflected in great part by the limited progress in construction of pollution abatement facilities. A number of factors have contributed to the lack of progress in efforts to combat water pollution as a whole. The lack of adequate legislative authority, the administration of existing legislation by several agencies with interest in water resources rather than by a single responsible water pollution control agency, and lack of sufficient funds and personnel necessary for the development and promotion of a water pollution control program are a few of the factors which have handicapped pollution abatement in the basin.

Although there have been considerable improvements in processes and equipment used for domestic and some industrial waste treatment, the lack of technical knowledge concerning satisfactory methods for treating certain complex industrial wastes has also retarded pollution abatement in the basin.

In recent years, however, the subject of stream pollution has received greater attention than ever before. Governmental agencies, professional and lay organizations and the general public are more cognizant of the serious consequences resulting from the increasing pollution which is defiling the streams and doing damage to the resources and to developments dependent upon the waters.

The State of Colorado recognizes its deficiencies in coping with the problem of water pollution and is currently engaged in the task of developing

TABLE E
ADEQUACY OF EXISTING TREATMENT FACILITIES
MUNICIPAL*

Number of Municipal* Treatment Facilities	Adequacy with Relation to:					
	Capacity			Operation		
	Satisf.	Unsatisf.	Undetermined	Satisf.	Unsatisf.	Undetermined
17	8	5	4	5	3	9

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

TABLE F
ADEQUACY OF EXISTING TREATMENT FACILITIES
INDUSTRIAL*

Number of Industrial* Treatment Facilities	Adequacy with Relation to:					
	Capacity			Operation		
	Satisf.	Unsatisf.	Undetermined	Satisf.	Unsatisf.	Undetermined
13	0	4	9	0	4	9

* Industries having separate outlets discharging wastes directly to watercourse.

TABLE G
PROGRESS IN CONSTRUCTION OF POLLUTION ABATEMENT FACILITIES

Year	Municipal		Industrial	
	Sewage Treatment Plants Completed	Design Population	Waste Treatment Plants Completed	Amount of Waste Treated (In terms of Equiv. No. People)
1946	0	-	0	-
1947	1	730	0	-
1948	0	-	0	-
1949	0	-	0	-
1950	2	2000	0	-

suitable and comprehensive legislation for the purposes of defining the responsibilities and authority for a unified and concerted attack upon water pollution within the State. The Governor has appointed a committee of nine representing the various interests concerned with water resources to study the problem and to prepare a suitable water pollution control law.

The Federal Government recognizes that the responsibility for water pollution control rests primarily with the States, but also regards conservation of the water resources as a national concern. From this consideration, recent Federal legislation has been enacted to assist the States in their program activities. The provisions of the Federal Water Pollution Control Act, Public Law 845, 80th Congress, have stimulated water pollution control activities in Colorado by providing technical service assistance and making Federal funds available for the conduct of investigations, research, surveys and studies related to the prevention and control of water pollution caused by industrial wastes. To date grants totaling $22,000 have been available for water pollution control activities in the State.

POLLUTION PREVENTION MEASURES REQUIRED

Present estimates of pollution prevention measures required in the basin are based on information which was available at the writing of this report. The needs considered herein are not intended to be complete and final, but are subject to changes and re-evaluation as additional data become available through future studies and investigations.

Assembling the available data pertaining to all aspects of water pollution has exposed deficiencies in the information and defines a definite need and primary objective considered necessary to develop a comprehensive program of water pollution control.

Experience has demonstrated the limitations of divided responsibility for the administration of existing State water pollution control laws among several departments of the State government. It is apparent from the present deficiencies resulting from the divided responsibilities for water pollution control in the State that all administrative authority be assigned to a single established department of the State government. Because public health is a major interest and an integral part of a water pollution control program, and also because the operating activities of the health department are closely associated with water pollution control activities, it is considered logical that administrative control be placed in the State Department of Public Health. It is believed desirable, however, that administrative latitude be provided to allow for independent action through a board or council containing representation of all interests concerned with the broad aspects of water pollution control.

Concurrently with the establishment of a single responsible agency, there should be enacted supplemental statutes to provide comprehensive and effective legislative authority as a necessary working tool for the designated agency. Such legislation may be patterned after the suggested State Water Pollution Control Act as recommended to the states by the Council of State Governments.

A review of the available data indicates there is an immediate need for the construction of waste treatment facilities by a substantial number of municipalities and industries discharging wastes into the watercourses of the basin.

Table H and Map No. 5 show that 20 municipalities, (including the State Penitentiary) with a combined sewered population of 47,900, need new plants for the treatment of wastes discharged raw to the watercourses. Two municipalities need enlargements or additions to the existing plants which now serve 61,200 persons, and 3 municipalities, with a combined sewered population of 3,400, need replacements of existing plants. The plant requirements for 8 municipalities with a combined sewered population of 57,000 are undetermined. Only 4 communities (including the State Reformatory) involving less than 2 percent of the total sewered population in the basin, require no projects.

Table I and Map No. 6 show the industrial waste pollution abatement needs. Specific waste treatment requirements include one new plant and 2 enlargements or additions to existing facilities. These projects include a

TABLE H

WASTE TREATMENT NEEDS - MUNICIPAL*

Needs	Number	Population Served by Facilities
New Plant	20	47,900
Enlargement or Additions to Existing Plant	2	61,200
Replace Existing Plant	3	3,400
No Project Required	4	2,300
Undetermined	8	57,000

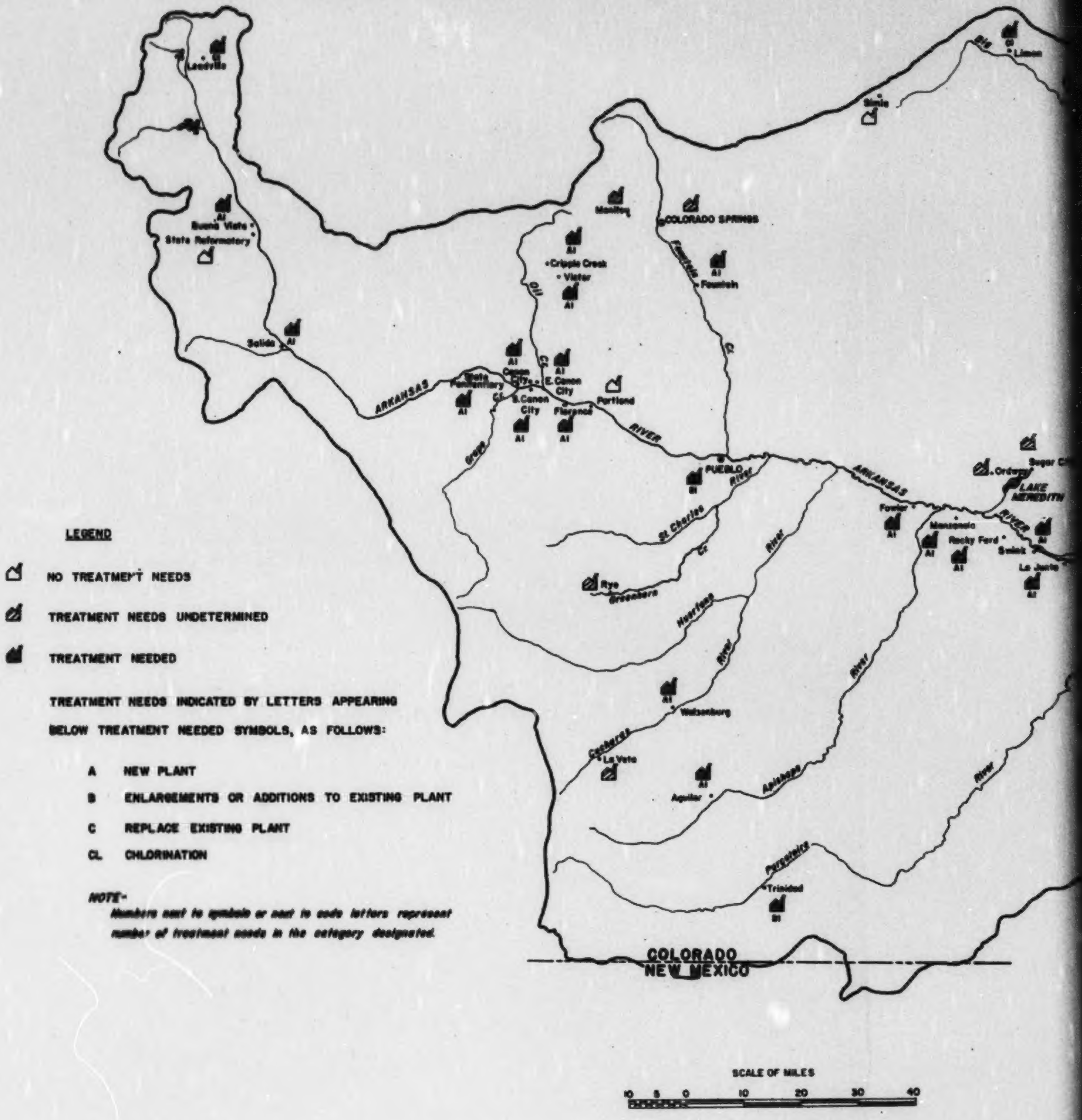
* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

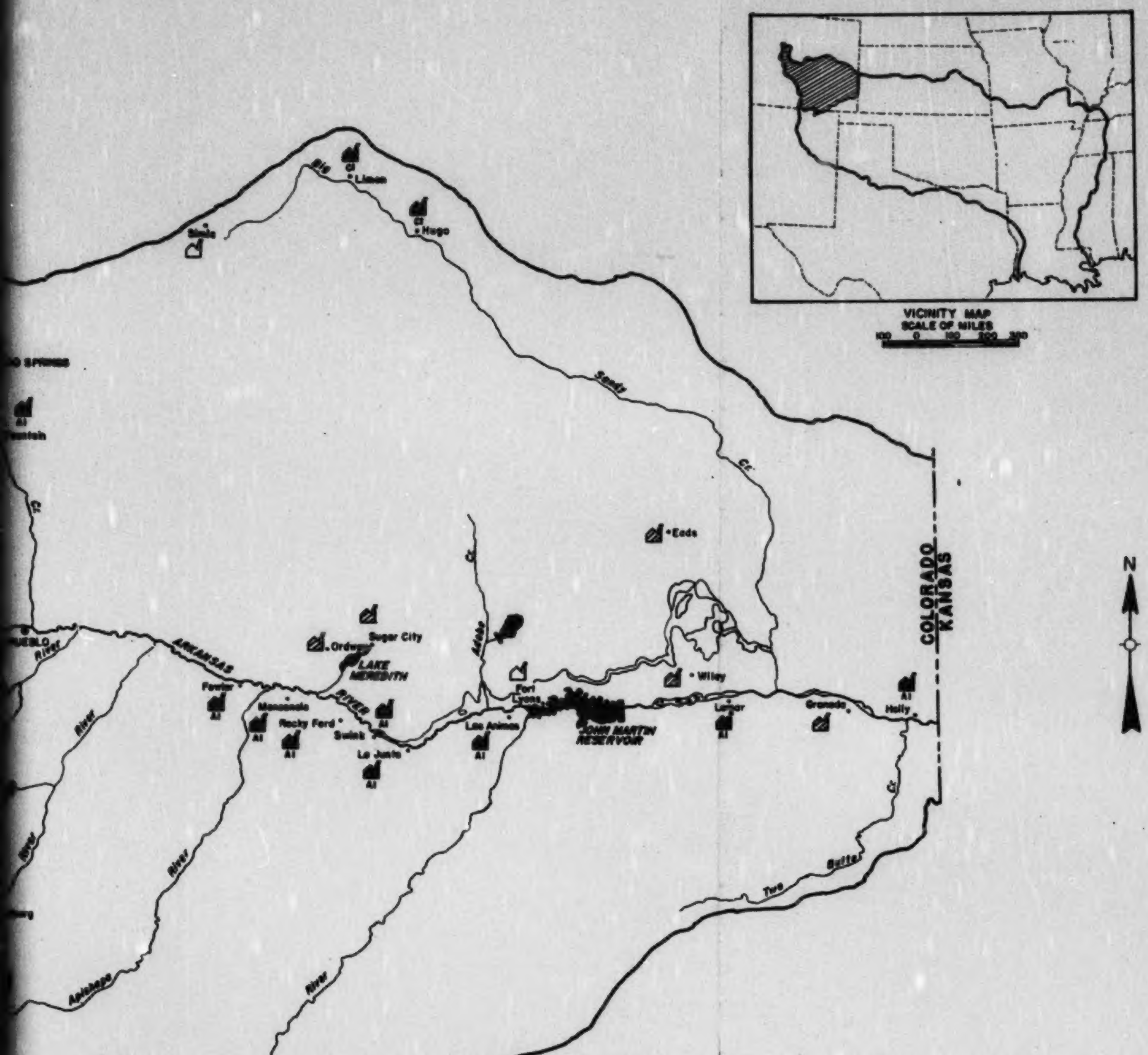
TABLE I

INDUSTRIAL* WASTE POLLUTION ABATEMENT NEEDS

Needs	Number
New Treatment Plant or other Pollution Control Measures	1
Enlargement or Additions to Existing Plant	2
Replace Existing Plant	0
Connection to Municipal Sewer System	14
No Project Required	0
Undetermined	13

* Industries having separate outlets discharging wastes directly to watercourse.


LEGEND
NO TREATMENT NEEDS
TREATMENT NEEDS UNDETERMINED
TREATMENT NEEDED
TREATMENT NEEDS INDICATED BY LETTERS APPEARING BELOW TREATMENT NEEDED SYMBOLS, AS FOLLOWS:
A NEW PLANT
B ENLARGEMENTS OR ADDITIONS TO EXISTING PLANT
C REPLACE EXISTING PLANT
CL CHLORINATION
NOTE- Numbers next to symbols or next to code letters represent number of treatment needs in the category designated.
Leadville
Buena Vista
State Reformatory
Salida
ARKANSAS
RIVER
State Penitentiary
Canon City
E. Canon City
S. Canon City
Florence
Portland
Cripple Creek
Victor
Oil Cr
Grape Cr
Manitou
COLORADO SPRINGS
Fountain Cr
Fountain
PUEBLO
St Charles Cr
Rye
Greenhorn
Huerfano River
Walsenburg
Cucharas River
La Veta
Aguilar
Apishapa River
Purgatoire River
Trinidad
Big
Limon
Simla
Sugar City
Ordway
LAKE MEREDITH
Fowler
Manzanola
Rocky Ford
Swink
La Junta
A1
B1
CL
COLORADO
NEW MEXICO
SCALE OF MILES
10 5 0 10 20 30 40


VICINITY MAP
SCALE OF MILES
100 0 100 200 300
Big
Cl
Limon
Cl
Hugo
Simla
Sandy
Cr.
SPRINGS
Al
Fountain
Cr.
Eads
COLORADO
KANSAS
N
Sugar City
Ordway
LAKE MEREDITH
Adobe
Cr.
PUEBLO
River
ARKANSAS
RIVER
Fowler
Al
Manzanola
Al
Rocky Ford
Al
Swink
Al
La Junta
Al
Fort Lyons
Las Animas
Al
JOHN MARTIN RESERVOIR
Wiley
Lamar
Al
Granada
Holly
Al
Cr.
Two
Butte
River
River
River
Apishapa
River
Purgatoire
Trinidad
Bl
DO
XICO
SCALE OF MILES
10 20 30 40

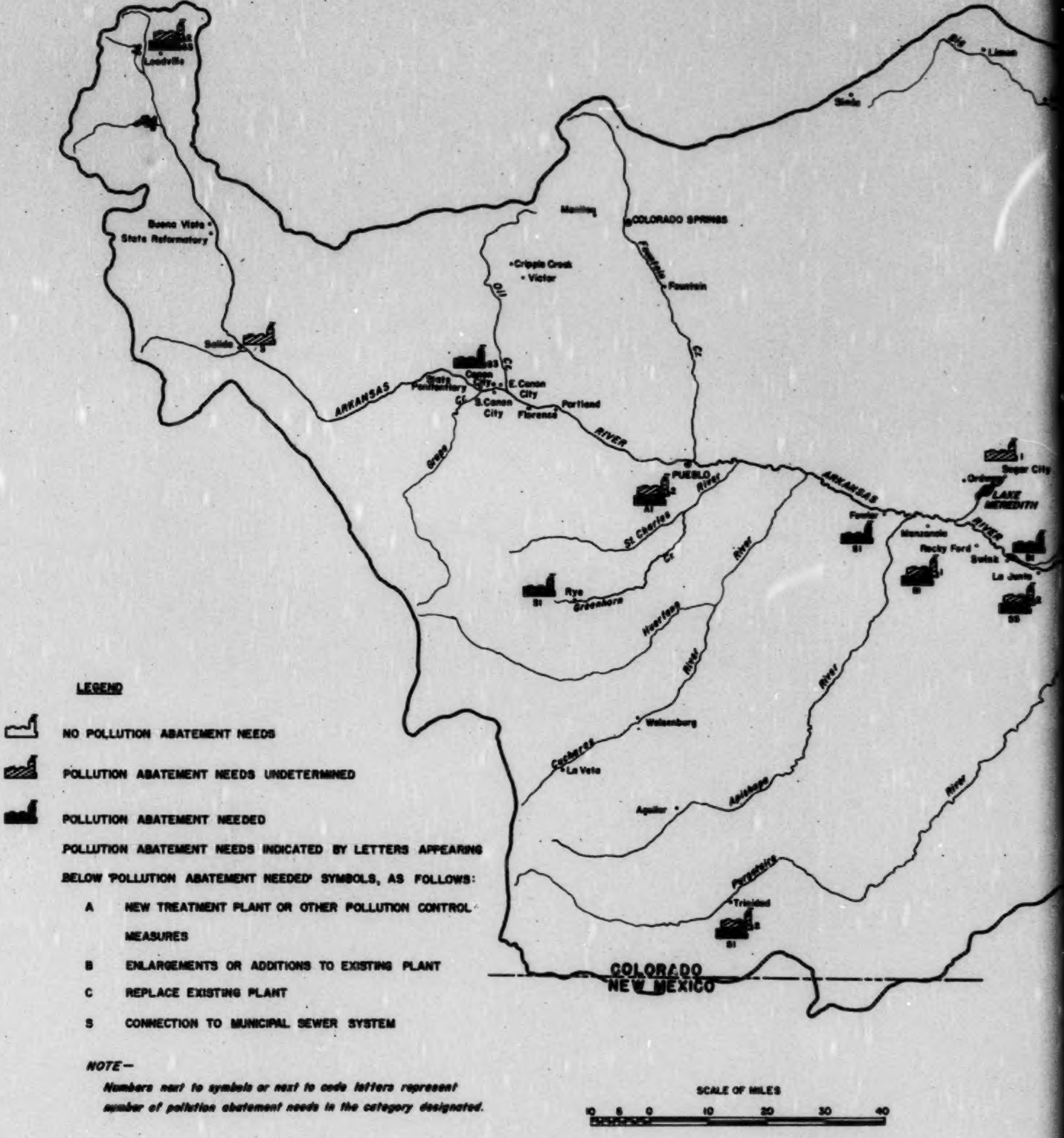
UPPER ARKANSAS RIVER BASIN
above Colorado, Kansas state line

MUNICIPAL

WASTE TREATMENT NEEDS

COLORADO DEPARTMENT OF PUBLIC HEALTH
FEDERAL SECURITY AGENCY - PUBLIC HEALTH SERVICE

MAP No. 5


Leadville
Buena Vista
State Reformatory
Salida
S
ARKANSAS
State Penitentiary
Canon City
S3
Cr.
Cr.
E. Canon City
S. Canon City
Florence
Portland
RIVER
Grape
Oil
Manitou
COLORADO SPRINGS
Cripple Creek
Victor
Fountain
Fountain
Cr.
PUEBLO
2
A1
River
St. Charles
Cr.
Rye
S1
Greenhorn
Huerfano
River
River
ARKANSAS
Fowler
S1
Manzanola
Rocky Ford
1
B1
Swink
La Junta
2
S5
1
Sugar City
Ordway
LAKE MEREDITH
RIVER
S1
Big
Limon
Simla
Walsenburg
Cucharas
La Veta
Aguilar
Apishapa
River
River
Purgatoire
Trinidad
2
S1
COLORADO
NEW MEXICO
SCALE OF MILES
10 5 0 10 20 30 40

LEGEND

▭ NO POLLUTION ABATEMENT NEEDS

▨ POLLUTION ABATEMENT NEEDS UNDETERMINED

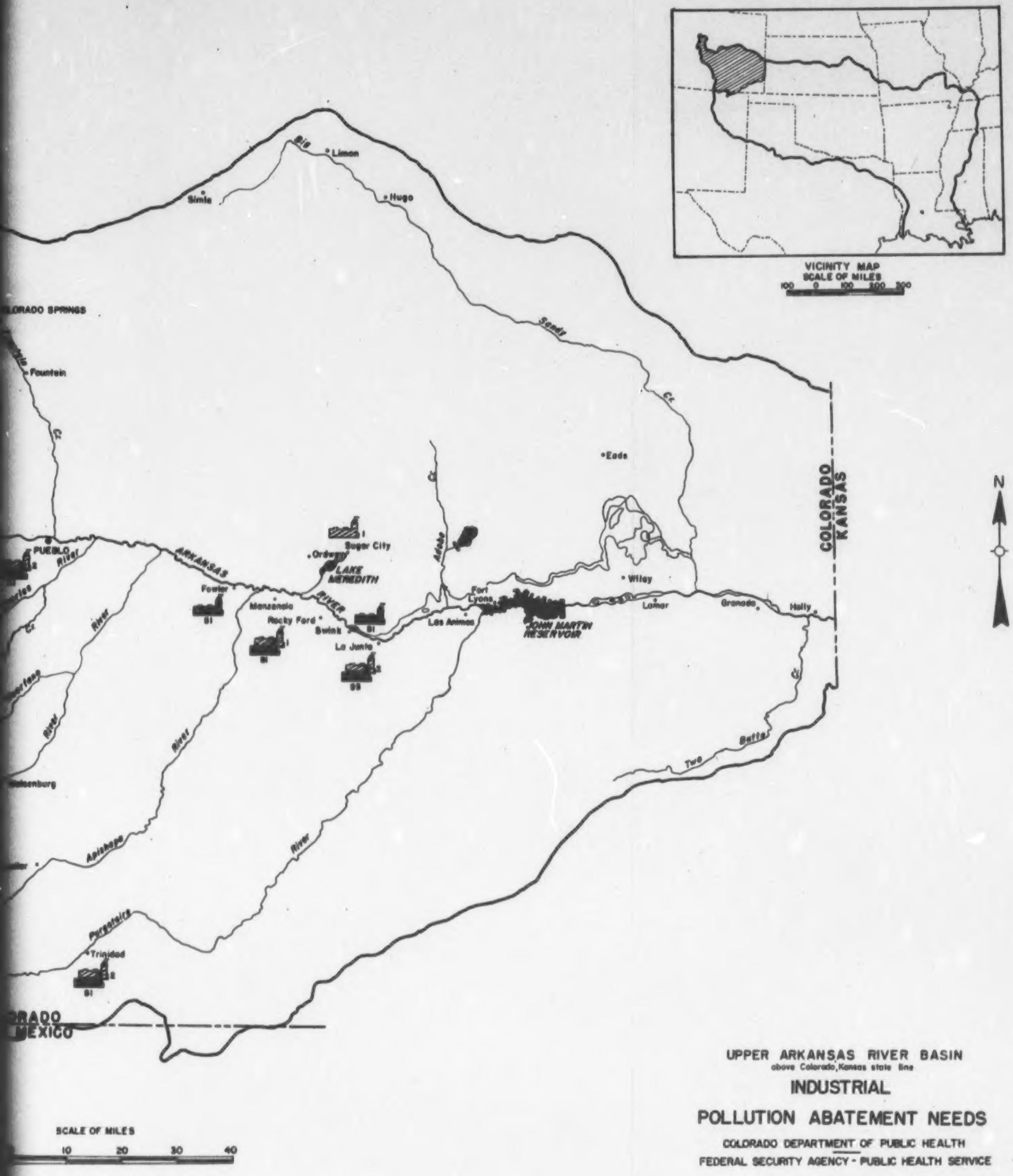
■ POLLUTION ABATEMENT NEEDED

POLLUTION ABATEMENT NEEDS INDICATED BY LETTERS APPEARING BELOW 'POLLUTION ABATEMENT NEEDED' SYMBOLS, AS FOLLOWS:

A	NEW TREATMENT PLANT OR OTHER POLLUTION CONTROL MEASURES
B	ENLARGEMENTS OR ADDITIONS TO EXISTING PLANT
C	REPLACE EXISTING PLANT
S	CONNECTION TO MUNICIPAL SEWER SYSTEM

NOTE—

Numbers next to symbols or next to code letters represent number of pollution abatement needs in the category designated.


VICINITY MAP
SCALE OF MILES
100 0 100 200 300
Big
Limon
Simla
Hugo
Sandy
Cr.
Eads
LORADO SPRINGS
Fountain
Cr.
PUEBLO
River
Sugar City
Ordway
LAKE MEREDITH
ARKANSAS
RIVER
Adobe
Cr.
Fowler
Manzanola
Rocky Ford
Swink
La Junta
Fort Lyons
Las Animas
JOHN MARTIN RESERVOIR
Wiley
Lamar
Granada
Holly
COLORADO
KANSAS
N
Two
Butte
Cr.
River
River
Apishapa
River
Purgatoire
Trinidad
lsenburg
RADO
MEXICO
1
2
S1
S2
SCALE OF MILES
10 20 30 40

UPPER ARKANSAS RIVER BASIN
above Colorado, Kansas state line

INDUSTRIAL

POLLUTION ABATEMENT NEEDS

COLORADO DEPARTMENT OF PUBLIC HEALTH
FEDERAL SECURITY AGENCY - PUBLIC HEALTH SERVICE

MAP No. 6

new plant needed for the treatment of steel mill wastes, and the enlargement of facilities of 2 beet sugar factories. Connection to municipal sewer systems is recommended for 14 industries. Included in this latter group are 6 dairies, 6 meat packing plants, 1 rendering plant, and 1 canning factory. The needs for 13 other industries are undetermined.

Table J shows the current status of action by municipalities requiring projects for pollution abatement. Thirty municipalities have taken no action on their needed projects. Final plans have been approved for the construction of 1 treatment plant, and active planning is indicated for 2 plants. No municipal waste treatment works are under construction at the present time.

The lack of action on the part of state institutions to provide needed sewage treatment facilities has hampered the efforts of both the State Water Pollution Control Agency and local authorities in encouraging the construction of waste treatment facilities.

A specific example in the basin is the State Penitentiary at Canon City which is discharging sewage from an inmate population of 1,250 directly to the Arkansas River without treatment.

The current status of action by industries requiring projects for pollution abatement is shown in Table K. Twenty-one industries have taken no action on their project needs, one project is under construction, and the status of eight needed projects is undetermined.

Table L lists the municipalities and the numbers of various industries needing projects for abatement of pollution in the basin. The population connected to municipal sewer systems or served by existing treatment facilities is represented as population served; data regarding the organic waste load produced by industries discharging to public sewers or directly to watercourses, however, are not available.

It is estimated that the initial cost of required municipal waste treatment facilities in the Upper Arkansas River Basin will be between $3,000,000 and $4,000,000. This estimate is based on average construction costs considered reasonable for this State and includes needed sewerage facilities in addition to treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged to municipal sewers.

The lack of data regarding sources of industrial pollution and the complexities involved in determing the type and magnitude of waste treatment facilities for the many and varied kinds of industries precludes an estimate of cost for providing required industrial waste treatment facilities in the basin.

In order to prevent further exploitation of the waters now seriously polluted, and to guard against similar conditions which may result from future population growth and industrial development, an early-action program should be initiated by the responsible State Water Pollution Control Agency in accordance with the pollution prevention and abatement measures outlined herein.

TABLE J

CURRENT STATUS OF MUNICIPAL* ACTION ON POLLUTION ABATEMENT NEEDS

Status of Action	Number of Municipalities*
Inactive	30
Active Planning	2
Final Plans Approved	1
Under Construction	0

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

TABLE K

CURRENT STATUS OF INDUSTRIAL* ACTION ON POLLUTION ABATEMENT NEEDS

Status of Action	Number of Industries*
Inactive	21
Active Planning	0
Final Plans Approved	0
Under Construction	1
Undetermined	8

* Industries having separate outlets discharging wastes directly to watercourse.

TABLE L

MUNICIPALITIES AND INDUSTRIES NEEDING IMPROVEMENTS FOR ABATEMENT OF POLLUTION

May 1, 1951

* For industries the organic waste load is expressed as population equivalent as measured by B.O.D.
1/ 1950 Census Population
2/ Includes Manitou

Name and Location	Population* Served	Improvements Needed	Remarks
Aguilar	1,044 1/	New sewer system and plant	Sewer system recommended by Colorado Dept. of Public Health
Buena Vista	776 1/	"	"
Canon City	6,313	New Plant	
2 Meat Packing Plants	-	Connect to city sewers	
1 Dairy	-	"	
Colorado Springs	53,000 2/	Undetermined	Adequacy of chemical precipitation and chlorination for downstream irrigation uses to be studied.
Colorado State Penitentiary	1,250	New Plant	
Cripple Creek	800	New Plant	
Eads	1,011	Undetermined	
East Canon	350	New Plant	
Florence	2,488	New Plant	
Fountain	711 1/	New sewer system and plant	Sewer system recommended by Colorado Dept. of Public Health
Fowler	1,016	New Plant	
1 Packing Company	-	Connect to city sewers	
Granada	483	Undetermined	
Holly	1,244	New Plant	
Hugo	845	Replacement	

TABLE L Continued

Name and Location	Population# Served	Improvements Needed	Remarks
La Junta	7,268	New Plant	
1 Canning Co.	-	Connect to city sewers	
2 Packing Co.	-	"	
1 Abattoir	-	Undetermined	
1 Dairy	-	Connect to city sewers	
1 Rendering Co.	-	"	
1 Railroad Shop	-	Undetermined	
Lamar	7,715	New Plant	
Las Animas	2,422	New Plant	
La Veta	696	Undetermined	
Leadville	1,223	Replacement	
1 Mining Co.	-	Undetermined	Mine drainage and tailings
3 Dairies	-	Connect to city sewers	
1 Smelting and Refining Co.	-	Undetermined	Ore washings
Limon	1,294	Replacement	
Manzanola	490	New Plant	
Ordway	1,162	Undetermined	
Pueblo	54,027	Enlargement and Additions	
2 Dairies	-	Undetermined	
1 Steel Plant	-	New plant or other pollution control measures	Wastes amount to 65-90 M.G.D.; include by-product coke wastes, spent pickle liquors, oil and scale from rolling mills.

TABLE L Continued

Name and Location	Population* Served	Improvements Needed	Remarks
Rocky Ford	3,269	New Plant	
1 Sugar Company	-	Enlargement	
1 Food Locker	-	Undetermined	Slaughterhouse
Rye	160	Undetermined	
1 Creamery	-	Connect to city sewers	
Salida	4,516	New Plant	
2 Fluorspar Co.	-	Undetermined	Mine tailings
1 Dairy	-	"	
South Canon	1,586	New Plant	
Sugar City	417	Undetermined	
1 Sugar Co.	-	"	
Swink	330	New sewer system and plant	Sewer system recommended by Colorado Dept. of Public Health
1 Sugar Co.	-	Enlargement	
Trinidad	7,200	Enlargement	
1 Packing Co.	-	Undetermined	
1 Packing Co.	-	Connect to city sewers	
1 Dairy	-	Undetermined	
Victor	677	New Plant	
Walsenburg	3,621	New Plant	
Wiley	83	Undetermined	

An effective operating program will require adequate administrative and technical personnel, necessary equipment and facilities, and sufficient funds for unrestricted operation. The program objectives should accomplish, through further studies and investigations, a comprehensive evaluation of the pollution problems, recommendations for their solution, and finally, the active sponsoring of remedial measures required. When essential, for the solution of certain industrial waste pollution problems, cooperative investigations and research projects between the State and industry should be encouraged and promoted by the responsible water pollution control agency. Such cooperative action is desirable for the mutual solution of pollution problems which in the past have hampered the development of a sound and reasonable program of pollution abatement.

The need for public support is essential for the promotion of an effective water pollution control program. Although the public is generally aware of pollution in the streams of the basin, the majority are not fully cognizant of the extent of pollution, of the damages resulting from pollution to all water uses, or the benefits accruing from restoration and protection of the waters for productive uses. A State program of public education reaching citizens in all walks of life would serve to create greater public demand for pollution abatement.

APPENDIX

TABLE 1a - BASIC DATA ON SOURCES OF MUNICIPAL POLLUTION

REVIEW OF STATE WATER POLLUTION CONTROL LAWS

WATER POLLUTION INVESTIGATION OF THE UPPER ARKANSAS RIVER

TABLE 2a - LABORATORY DATA - SUMMARY OF INDIVIDUAL RESULTS

TABLE 1 a
BASIC DATA ON SOURCES OF MUNICIPAL* POLLUTION
UPPER ARKANSAS RIVER BASIN

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.
** Includes industrial wastes discharged into municipal sewerage systems.
*** Indicates screening and/or comminution.
A River Mile Above Mouth of Outlet Stream.
1/ 1950 Census Population
2/ Population Equivalent of Industrial Wastes discharged to sewers undetermined.

Name and Location	River Mile A	Population Served by Sewers	P.E. (B.O.D.) Untreated Wastes **	Waste Treatment Provided	Adequacy of Treatment Facilities		P. E. (B.O.D.) Disch'd to Water-course **	Treatment Needs	Current Status Municipal* Action
					Cap'y	Opr.			
Arkansas River (main stem)									
Leadville	1,450	1,223	1,223	Primary	Unsat.	Unsat.	1,100	Replacement	Final plans approved
Buena Vista	1,401	776 1/	No existing sewer system				-	New sewers and plant	Inactive
Colo. State Reformatory	1,400	250	250	Primary	Sat.	Undet'd	Subsurface disposal	None	-
Salida	1,375	4,516	4,516 + 2/	None	-	-	4,516 + 2/	New Plant	Inactive
Canon City	1,323	6,313	6,313 + 2/	None	-	-	6,313 +	New Plant	Active Planning
Colo. State Penitentiary	1,323	1,250	1,250	None	-	-	1,250	New Plant	Inactive
South Canon	1,323	1,586	1,586	None	-	-	1,586	New Plant	Inactive
East Canon	1,320	350	350	None	-	-	350	New Plant	Inactive
Florence	-	2,488	2,488 + 2/	None	-	-	2,488 + 2/	New Plant	Inactive

TABLE 1aContinued

Name and Location	River Mile A	Population Served by Sewers	P. E. (B.O.D.) Untreated Wastes **	Waste Treatment Provided	Adequacy of Treatment Facilities		P. E. (B.O.D.) Disch'd to Water-course **	Treatment Needs	Current Status Municipal* Action
					Cap'y	Opr.			
Portland	1,305	205	205	Secondary	Sat.	Sat.	82	None	-
Pueblo	1,279	54,027	54,027+ 2/	Primary	Unsat.	Sat.	37,818+ 2/	Enlargement	Inactive
Fowler	-	1,016	1,016+ 2/	None	-	-	1,016+ 2/	New Plant	Inactive
Manzanola	-	490	490	None	-	-	490	New Plant	Inactive
Rocky Ford	1,210	3,269	3,269+ 2/	None	-	-	3,269+ 2/	New Plant	Inactive
Swink	-	330	No existing sewer system			-	-	New sewers and plant	Inactive
La Junta	1,196.5	7,268	7,268+ 2/	None	-	-	7,268+ 2/	New Plant	Inactive
Las Animas	1,175	2,422	2,422	None	-	-	2,422	New Plant	Inactive
Fort Lyons	1,168.5	1,500	1,500	Primary	Sat.	Sat.	1,050	None	-
Lamar	1,135.6	7,715	7,715+ 2/	None	-	-	7,715+ 2/	New Plant	Inactive
Holly	1,103.4	1,244	1,244+ 2/	None	-	-	1,244+ 2/	New Plant	Inactive
Oil Creek	Ark. 1,318.6								
Cripple Creek	-	800	800	None	-	-	800	New Plant	Inactive
Victor	-	677	677	None	-	-	677	New Plant	Inactive

TABLE 1a Continued

Name and Location	River Mile A	Population Served by Sewers	P. E. (B.O.D.) Untreated Wastes **	Waste Treatment Provided	Adequacy of Treatment Facilities		P. E. (B.O.D.) Disch'd to Water-course **	Treatment Needs	Current Status Municipal* Action
					Cap'y	Opr.			
Fountain Creek	Ark. 1,277.5								
Manitou	-	2,574	2,574	Sewage discharged to Colorado Springs plant.					
Colorado Springs	-	50,426	50,426+ 2/	Primary	Sat.	Undet'd	37,100+ 2/	Undetermined	Inactive
Fountain	-	711 1/	No existing sewer system		-	-	-	New sewers and plant	Inactive
Subsurface									
Rye	-	160	160	Primary	Undet'd	Undet'd	Subsurface	Undetermined	Inactive
Cucharas River	H1253.4								
La Veta	-	696	696	Primary	Undet'd	Undet'd	487	Undetermined	Inactive
Walsenburg	-	3,621	3,621 2/	None	-	-	3,621 2/	New Plant	Inactive
Apishapa River	Ark. 1,235								
Aguilar	-	1,044 1/	No existing sewer system			-	-	New sewers and plant	Inactive
Lake Meridith	Ark. 1,210								
Ordway	-	1,162	1,162	Primary	Undet'd	Undet'd	813	Undetermined	Inactive
Sugar City	-	417	417	Primary	Undet'd	Undet'd	292	Undetermined	Inactive

TABLE 1a Continued

Name and Location	River Mile A	Population Served by Sewers	P. E. (B.O.D.) Untreated Wastes **	Waste Treatment Provided	Adequacy of Treatment Facilities		P. E. (B.O.D.) Disch'd to Watercourse **	Treatment Needs	Current Status Municipal* Action
					Cap'y	Opr.			
Purgatoire River	Ark. 1,171.6								
Trinidad	-	7,200	7,200+ 2/	Secondary	Unsat.	Sat.	2,888 + 2/	Enlargement	Inactive
Subsurface									
Wiley	-	83	83	Primary	Sat.	Undet'd	Subsurface	Undetermined	Inactive
Dry Gulch									
Eads	-	1,011	1,011	Primary	Sat.	Undet'd	Surface	Undetermined	Inactive
Big Sandy Creek									
Simla	-	400	400	Primary	Sat.	Sat.	280	None	-
Limon	-	1,294	1,294	Primary	Unsat.	Unsat.	908	Replacement	Active Planning
Hugo	-	845	845	Primary	Unsat.	Unsat.	590	Replacement	Inactive
Wolf Creek	Ark. 1,114								
Grenada	-	483	483	Primary	Sat.	Undet.	338	Undetermined	-

REVIEW OF STATE WATER POLLUTION CONTROL LAWS

(Statutory references are to the Colorado
Statutes Annotated, 1935, as amended, Cum.
Supp. 1949)

1. General Statement

Colorado legislation dealing with water pollution control falls into four main categories: (1) the public health laws; (2) the game and fish laws; (3) a special law concerning pollution in the South Platte River and Bear Creek and their tributaries; and (4) the criminal laws.

1. Public Health Laws

The State Department of Public Health Reorganization Act of 1947 (Secs. 21(1), et seq., Ch. 78, Cum. Supp.) revised and collected (in part) State legislation relating to Public Health. In the process of this revision legislation dealing with specific subject matter such as the control of water pollution for public health purposes was repealed, and revised provisions were adopted which are mostly in general terms including within their scope various aspects of public health control without identifying the particular, such as water pollution control. The apparent purpose was to invest the Department of Public Health with broad powers over all phases of public health. Whether the sponsors fully succeeded in this purpose has not been tested in the courts.

2. Game and Fish Laws

The game and fish laws make it unlawful to deposit sawdust, mill tailings, or other deleterious substances into any public waters containing fish, and place in the Game and Fish Department authority to enforce these laws (Secs. 158, et seq., Ch. 73). The enforcement power given the Game and Fish Department by the statute, however, is limited to bringing actions to enjoin the pollution, with the court in determining the case directed to consider among other things "the public necessity and importance of the industry concerned as compared with the like necessity and importance of such waters as a source of fish supply" (Sec. 164, Ch. 73). In practice the Game and Fish Department has assumed a broader jurisdiction over pollution as it may affect fish life, apparently relying on its implied powers. Because of the lack of further statutory implementation the following analysis does not include a development of the organization, power, processes, etc., of the Game and Fish Department.

3. South Platte River and Bear Creek

A law passed originally in 1907 makes unlawful the pollution or defilement of the waters of the South Platte River and Bear Creek and their tributaries above the mouth of Clear Creek with the exception that "disturbances of water by placer mining or tailings from ore reduction mills flowing into any of the said streams or tributaries shall not be construed as a defilement or pollution of the water thereof." The law goes on to provide that the City and County of Denver is "given jurisdiction over said streams to protect their purity and is hereby authorized to provide by ordinances for the patrol of said stream and for the punishment of offenders." Further provisions are to the same effect respecting waters in the channel of the

South Platte River (Secs. 4-9, Ch. 53). While the question has not been tested in the courts, the better view appears to be that these provisions do not exclude State jurisdication over pollution of the waters of the South Platte River and Bear Creek which may affect the general public health, as distinguished from pollution which may be of local concern.

4. Criminal Statutes

Sec. 258. Polluting streams--Penalty. If any person or persons shall hereafter throw or discharge into any stream of running water, or into any ditch or flume in this state, any obnoxious substance, such as refuse matter from slaughter house or privy, or slops from eating houses or saloons, or any other fleshy or vegetable matter which is subject to decay in the water, such person or persons shall upon conviction thereof, be punished by a fine not less than one hundred dollars nor more than five hundred dollars for each and every offense so committed.

WATER POLLUTION INVESTIGATION OF UPPER ARKANSAS RIVER BASIN

By

Colorado State Department of Public Health

(Oct. 15, 1950 - Jan. 20, 1951)

Study Methods

In planning the stream pollution investigation of the Upper Arkansas River Basin, it was recognized that because of limitations imposed upon the State Department of Public Health by the lack of sufficient funds and personnel, a limited program was possible. The basin was divided into six work areas, and each area was sampled for at least a week. A laboratory was first set up in the Salida High School. Samples taken between Leadville and Salida were analyzed at this laboratory. Later as the study progressed, the laboratory was moved to the Pueblo Sewage Disposal Plant. From this laboratory the following areas were sampled:

1. Canon City to Pueblo
2. Pueblo to La Junta
3. La Junta to Holly
4. Colorado Springs to Pueblo
5. Trinidad & Walsenburg area.

In addition, studies were also conducted on Salt Creek and Lake Meridith.

Sampling Procedure

Stream sampling stations were established above and below sources of known or suspected pollution. In areas where significant pollution was expected intermediate points were added. Conveniently located bridges were utilized wherever possible for sampling locations. In the absence of bridges, suitable walk-in points were selected.

The sample collector recorded the time of day to the nearest minute when a sample was collected and determined the temperature of the water to the nearest degree. The sample collector also recorded as "remarks" any unusual stream conditions.

Samples were transported in special carrying cases. The cases, which were war surplus insulated food containers, were fitted with bottle racks and an ice compartment. Samples were placed in the insulated box as soon as collected and remained there until ready for analysis. Samples, in most cases, were collected in the morning and would be in the laboratory by early afternoon so that analyses could be initiated with a minimum of elapsed time.

Number of Sampling Stations

A total of 46 sampling points for chemical and bacteriological samples were established. Two hundred and eighty-two samples were collected. In addition, samples and analyses were made on some industrial wastes.

Laboratory Tests and Their Significance

Routine laboratory tests included temperature, turbidity, dissolved oxygen, biochemical oxygen demand, pH, alkalinity, and coliform group organisms.

Temperature - The temperature of the water governs the rates of reoxygenation and reaeration and the oxygen saturation level.

Dissolved Oxygen - Dissolved oxygen is a measure of the amount of oxygen available in a stream to satisfy need for aquatic life, self purification and other oxidation requirements. Normally, there is 9.17 p.p.m. of oxygen dissolved in stream water at 20° C. and 760 m.m. barometric pressure. This value is a function of water temperature and atmospheric pressure. Supersaturation may be brought about by the photosynthetic action of some water plants or by aeration of the stream water through excessive turbulence. Dissolved oxygen values below the saturation level are an indication of the presence of organic pollution which utilize oxygen from the stream water. A measure of the degree of pollution of a particular area is given by the deficiency in the dissolved oxygen content below saturation.

Biochemical Oxygen Demand - The standard test for biochemical oxygen demand (B. O. D.) requires five days of incubation at 20° C. of sealed samples of water under examination of the loss of dissolved oxygen during that time. Where the loss may be greater than the initial dissolved oxygen present, the sample is diluted with standard B.O.D. free dilution water and the measured loss multiplied by the appropriate dilution factor.

The B.O.D. thus determined becomes a measure of the amount of oxygen necessary to satisfy the biochemical oxidation requirements of the pollution at the time the sample was collected. Since the amount of dissolved oxygen present decreases with rising temperatures and at the same time the rate of biochemical oxidation increases as the temperature, critical stream conditions result during the warm months, particularly since these high temperatures are often combined with low stream flows.

pH - The pH value indicates the relative intensity of acidity or alkalinity of a water, with the neutral point at pH 7.0. Values lower than 7.0 indicate the presence of acids, above pH 7.0 to 14.0 the presence of alkalies.

Alkalinity - The Alkalinity of a water usually indicates the presence of carbonates, bicarbonates, hydroxides and sometimes borates, silicates and phosphates.

Coliform Group Organisms - This determination gives the most accurate estimation of the degree of pollution by sewage, since it shows the approximate density of sewage type organisms that are normally found only in very small numbers in natural unpolluted streams. Coliform bacteria are normally present in the intestines of warm-blooded animals and are discharged in vast numbers in human feces, which constitute the main source of these bacteria in sewage.

Laboratory Procedures

All analyses, both chemical and bacteriological, were made in accordance with "Standard Methods for the Examination of Water and Sewage" Ninth Edition, 1946, of the American Public Health Association.

Table 2a - UPPER ARKANSAS RIVER BASIN

LABORATORY DATA - SUMMARY OF INDIVIDUAL RESULTS

(Survey by Colo. Dept. of Public Health - Oct. 15, 1950 - Jan. 20, 1951)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Calif. Gulch 100 yds. above Leadville sewer outfall.	10:40A 10-18-50		10	-	-	-	5	>50	22
	6:45A 10-20-50		5	3.9	-	93	4.8	>50	20
	9:20A 10-23-50		7	-	-	0	4.5	>50	35
	8:40A 10-25-50		-			1,100			
	8:20A 11-14-50		-	5.7	.3	0		15	
	8:20A 11-15-50		-	4.9	-			31.5	
	8:45A 11-16-50		-	7.1	-			23	
Calif. Gulch off bridge on Hwy. 24 1 mi. below Leadville sewage outfall.	10:45A 10-18-50		10	-	-	-	7	>50	32
	7:00A 10-20-50		5	5.67	-	930	4.2	>50	15
	9:35A 10-23-50		7	-	-	93,000	5	>50	40
	8:50A 10-25-50		-		-	>230,000			
	8:35A 11-14-50		-	8.1	>6.6	430		27	
	8:55A 11-15-50		-	6.5	-			40	
	9:00A 11-16-50		-	8.2	-			35	
Ark. River above confluence with Calif. Gulch (mileage from mouth - 1447)	11:00A 10-18-50		10	9	-	-	6	1.8	89.5
	8:10A 10-20-50		6	9	-	0	6	1.4	97

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River above confluence with Calif. Gulch (mileage from mouth - 1447)	9:50A 10-23-50		6	9.33	-	0	5.2	1.1	98
	9:00A 10-25-50		-		-	3.6			
	8:50A 11-14-50		-	9.2	.7	43		5.6	
	9:10A 11-15-50		-	10.2	1.9			12.2	
	9:15A 11-16-50		-	9.9	1.4			3.7	
Ark. River off bridge on Hwy. 24 3½ miles below Malta (mileage from mouth - 1443.5)	11:30A 10-18-50		10	9.9	-	-	6	8	78
	8:30A 10-20-50		6	9.8	-	0	5.7	10.5	77
	10:10A 10-23-50		6	9.9	-	93	6.2	3	116
	9:20A 10-25-50		-			430			
	9:00A 11-14-50		-	10	2.7	93		12.2	
	9:25A 11-15-50		-	10.5	1.0	-		7.9	
	9:30A 11-16-50		-	10.6	1.5	-		3.5	
Ark. River at Buena Vista old power-house dam. (mileage from mouth - 1401)	7:10A 10-19-50		9	9.02	-	-	6.0	3.4	60
	9:20A 10-20-50		9			430			
	8:00A 10-24-50		9	9.95	-	9.1	5.0	3.1	56
	9:40A 11-14-50		-	11	0.2	0		10.7	
	10:15A 11-15-50		-	11	1.2	-		7.9	

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River at Buena Vista old powerhouse dam (mileage from mouth - 1401).	10:15A 11-16-50		-	11.4	1.6	-		3.7	
Ark. River below Buena Vista at bridge on Hwy. 24 (mileage from mouth-1400)	8:10A 10-19-50		9	8.83	-		6.0	2.5	58
	8:30A 10-24-50		9	9.4	-	460	5.0	2.75	67
	10:05A 11-14-50		-	10.8	.7	4300		12.3	
	10:40A 11-15-50		-	10.4	1.1	-		5.5	
	10:50A 11-16-50		-	11.2	1.6			4.5	
Ark. River above Salida at bridge on Hwy. 291 (mileage from mouth - 1375)	1:40P 10-18-50		14	8.9	-	-	5.5	2.4	112.5
	8:50A 10-19-50		10	8.42	-	-	5.8	2.65	113
	10:20A 10-20-50		11	9.5	-	0	6.5	1.4	122
	11:10A 10-23-50		11	9.4	-	29	6.0	2.2	134
	9:10A 10-24-50		6	9.9	-	93	5.5	3.0	115
	10-25-50		-			230			
	10:35A 11-14-50		-	10.7	.5	23		7	
	11:20A 11-15-50		-	11.4	.3	-		5.5	
	11:20A 11-16-50		-	11.2	1.2			2.5	

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River 2 miles below Salida (mileage from mouth - 1373)	2:00 P 10-18-50		14	9.5	-	-	6.5	2.6	122
	9:20A 10-19-50		10	8.84	-	-	5.8	1.6	126
	11:10A 10-20-50		11	9.6	1.76	0	6.0	1.9	128
	11:30A 10-23-50		11	10.5	-	93,000	5.8	4.5	128
	9:30A 10-24-50		6	10.1	-	43,000	6.0	2.45	108
	10-25-50		-		2.96	23			
	10:50A 11-14-50		-	10.3		43,000		2.7	
	11:30A 11-15-50		-	11.0	1.40	-		8.7	
	11:30A 11-16-50		-	11.3	1.90	-		3.2	
Ark. River 2 miles above Parkdale (mileage from mouth - 1334)	9:15A 11-2-50		10	10.5	1.8	36	6.0	1.4	140
	9:40A 11-6-50		-	12.0	1.0	140	6.5	2.8	139
	8:07A 11-8-50		-	10.5	2.8	140	6.0	2.6	133
	9:10A 11-9-50		-	11.8	3.25	1500	5.5	8.5	120
	9:15A 1-9-51		1	12.4	1.1 0.9	-	6.0	3.85	130
	9:15A 1-10-51		1	12.3	1.8 1.3			11.2	130

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River ¼ mile below Parkdale (mileage from mouth - 1332)	9:50A 11-2-50		10	10.9	2.0	91	6.0	1.6	140
	10:00A 11-6-50		-	11.5	-	230	6.5	3.6	138
	8:20A 11-8-50		-	10.7	5.6	200	5.8	2.3	131
	9:40A 11-9-50		-	11.9	4.0	430	5.5	12.3	120
	9:25A 1-9-51		1	12.6	.7 .9	-	6.0	5.5	120
	9:25A 1-10-51		0	12.8	.6 .8			9.1	138
Ark. River 1 mile above Canon City (mileage from mouth-1324.3)	10:25A 11-2-50		-	10.7	-	300	6	.8	141
	10:20A 11-6-50		-	11.0	1.2	36	6.8	3.6	137
	8:45A 11-8-50		-	10.8	-	36	6.0	1.7	136
	10:25A 11-9-50		-	-	2.0	2,300	5.0	7.4	131
	9:50A 1-9-51		1	12.0	1.1 1.7	-	6.0	6.1	168
	9:35A 1-10-51		1	12.2	1.4 1.5	-		8.1	138
Ark. River 2 miles below Canon City (mileage from mouth - 1320)	11:40A 11-2-50		-	12.1	-	93,000	6	2.7	161
	10:40A 11-6-50		-	12.0	-	75,000	6.8	2.1	159
	9:05A 11-8-50		-	10.7	7.2	39,000	6.0	4.45	159
	11:00A 11-9-50		-	12.5	1.45	75,000	5.5	12.4	146

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River $1\frac{1}{2}$ miles above Florence outfall (mileage from mouth - 1315)	12:01P 11-2-50		-	10.85	3.0	43,000	5	3.2	219
	11:00A 11-6-50		-	11.8	3.0	9,300	6.5	3.95	187
	9:20A 11-8-50		-	10.9	2.4	21,000	6.0	3.6	207
	11:20A 11-9-50		-	12.5	3.8	43,000	6.0	8.5	165
	10:15A 1-9-51		1	11.6	.9 .9	-	6.5	4.1	118
	9:55A 1-10-51		1	12.0	1.8 1.9		-	11.9	166
Ark. River $1\frac{1}{2}$ miles below Florence (mileage from mouth-1313.5)	12:55P 11-2-50		-	12.0	6.0	120,000	5.5	2.75	178
	11:15A 11-6-50		-	12.4	-	75,000	6.8	3.7	175
	9:40A 11-8-50		-	11.5	5.6	93,000	6.0	4.35	171
	11:40A 11-9-50		-	12.2	3.4	7,500	6.0	7.0	215
	10:30A 1-9-51		1	11.5	.8 1.0		6.5	4.5	176
	10:05A 1-10-51		1	12.0	1.8 1.8		-	17	206
Ark. River at bridge on Hwy. 50 above Portland outfall (mileage from mouth - 1308)	8:35A 11-3-50		-	11.1	1.0	23,000	6.0	3.65	187
	8:50A 11-7-50		-	11.5	3.0	43,000	6.5	4.2	184
	9:05A 11-10-50		-	12.3	3.3	9,300	6.0	7.95	145
	10:45A 1-9-51		1	12.6	1.0 1.1	-	6.0	13.0	156
	10:15A 1-10-51		1	12.4	2.0 1.8	-	-	32	164

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River 1 mile below Portland (mileage from mouth - 1306)	9:15A 11-3-50		-	12.3	-	9,300	6.5	3.75	187
	9:25A 11-7-50		-	11.6	3.2	150,000	6.5	4.45	189
	9:30A 11-10-50		-	12.9	3.2	23,000	6.5	18.5	141
Ark. River at the intake to Pueblo's South Side Water Plant (mileage from mouth - 1280)	2:45P 11-2-50		-	10.7	.8	230	6.0	2.4	184
	10:17P 11-3-50		-	11.7	2.0	930	6.5	2.9	200
	1:35P 11-6-50		-	10.4	-	230	6.8	2.5	184
	10:30A 11-7-50		-	11.1	2.2	230	6.5	4.1	185
	10:50A 11-8-50		-	11.0	1.8	930	6.0	3.2	183
	1:45P 11-9-50		-	12.7	2.2	390	5.0	5.0	178
	10:25A 11-10-50		-	12.7	4.4	430	6.0	27.5	182
	11:30A 1-9-51		1	12.5	1.2 1.1	-	6.5	40	194
	11:00A 1-10-51		0	12.8	1.6 1.4	-	-	28	196
Ark. River at Baxter bridge 6 miles below Pueblo (mileage from mouth 1270)	3:20P 11-2-50		-	6.0	5.7 21.6	2,300,000	6.0	12.3	178
	10:50A 11-3-50		-	5.9	>5.9 7.6	4,300,000	6.8	69	188
	2:10P 11-6-50		-	0.7	2.0	2,300,000	5.0	21.5	54
	11:00A 11-7-50		-	4.0	15.0	1,500,000	5.5	26.5	110
	11:20A 11-8-50		-	6.1	17.0	2,100,000	6.0	10.5	168

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River at Baxter bridge 6 miles below Pueblo (mileage from mouth 1270)	2:20P 11-9-50		-	0.3	5.2	9,300,000	5.0	320	93
	10:55A 11-10-50		-	7.3	14.0	9,300,000	6.5	800	125
	12:50P 1-9-51		9	7.5	8.8 8.8	-	5.5	23	164
	11:25A 1-10-51		6	8.5	7.6 6.8	-	-	23.5	180
Ark. River 1 mile north of Fowler on Hwy. 167 (mileage from mouth - 1238)	9:30A 11-27-50		6	10.5	8.7	7,300	6.0	450	188
	9:05A 11-29-50			10.7	10.62 9.22 11.36 12.16	430,000		430	
	7:50A 11-30-50		2	11.2	9.2 9.8 11.6 11.2	390,000	6.5	390	174
Ark. River 1 mile north of Manzanola on Hwy. 207 (mileage from mouth - 1228)	10:10A 11-27-50		7	10.9	5.2	21,000	6.5	700	204
	9:30A 11-29-50			11.1	7.2 6.8 7.2 7.6	210,000	6.5	450	194
	8:20A 11-30-50		3	11.5	6.2 6.2 9.6 13.6	230,000	6.5	400	196
Meridith Lake at outlet to irrigation ditch	11:00A 11-28-50		4	10.7	5.6	0	5.5	165	264
	8:45A 11-30-50		4	10.7	6.8 6.0 5.6 5.6	0	6.8	15.5	132

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River at Rocky Ford above sewer outfall (mileage from mouth - 1210)	12:10P 11-20-50			11.0	-		6.0	550	212
	9:10A 11-30-50		10	44	> 7.6 > 7.6 >22.4 >22.4	2,300,000	6.5	470	290
	9:35A 12-11-50		1	11.7	10.2 10.4	230	6.0	1,500	282
	9:25A 12-13-50		3	11.2	10.0 8.0		6.0	650	206
	10:10A 1-8-51		1	12.1	3.2 3.4 5.6 3.2		6.0	250	224
	9:20A 1-11-51		1	11.8	3.2 3.4 6.8 2.8		-	205	256
Ark. River 1½ miles below Rocky Ford on Dye Reservoir Road (mileage from mouth - 1207)	11:05A 11-27-50		13	4.5	330	1,500,000	6.5	600	310
	9:50A 11-28-50		11	4.8	>28	1,500,000	6.0	600	258
	10:00A 11-29-50			4.8	>23 >10.2	9,300,000	6.8	500	266
	9:10A 11-30-50		10	4.4	> 7.6 >22.4	2,300,000	6.5	470	280
	8:20A 12-1-50			9.3	>14.7 23 22.6	23,000	6.8	110	208
	9:50A 12-11-50		7	9.0	74 70 70 66.7	750	6.5	800	236
	9:50A 12-13-50		7	8.0	72 72 67 70		6.5	525	248

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River 1½ miles below Rocky Ford on Dye Reservoir Road (mileage from mouth - 1207)	10:25A 1-8-51		3	10.1	20 20 24 20		6.5	163	254
	9:45A 1-11-51		2	9.7	12 12 26.7 20		-	128	288
Ark. River above Swink (mileage from mouth - 1204)	10:50A 12-11-50		3	10.8	12.8 12.8	1,200	6.5	700	248
	10:05A 12-13-50		4	9.4	19.2 18.8		5.8	450	226
	10:40A 1-8-51		2	11.7	5.2 5.0 5.2 5.2		6.5	420	233
	10:00A 1-11-51		2	11.3	2.2 2.4 3.6 2.4		-	197	252
Ark. River 2½ miles below Swink (mileage from mouth - 1201)	10:20A 11-28-50		9	9.5	> 27.6	2,300	6.0	165	138
	9:55A 12-1-50			5.0	> 27.2 > 74	9,300,000	6.5	450	303
	10:25A 12-11-50		3	9.8	22 20 23.3 20		6.8	750	354
	10:25A 12-13-50		6	10.5	20 22 6.6 6.6		6.0	190	242
Ark. River north of La Junta on Hwy. 196 (mileage from mouth - 1196.5)	11:35A 11-27-50		11	8.1	25.6	3,600	6.5	312	278
	10:20A 11-29-51			8.8	50 40	23,000	5.8	450	456

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River north of La Junta on Hwy. 196 (mileage from mouth - 1196.5)	9:35A 11-30-50		4	9.3	20 10 180 120	150,000	7.0	49	276
	10:50A 1-8-51		1	10.0	14.6 14.0 13 11		7.0	600	270
	10:20A 1-11-51		2	11.3	3.3 4.0 3.0 1.0		-	215	254
Ark. River 200 yds. below La Junta sewer outfall (mileage from mouth - 1195)	11:55A 11-27-50		12	5.9	130		6.8	155	314
	10:35A 11-29-50			6.6	73 60 56 70	120,000	7.0	115	322
	9:50A 11-30-50		6	7.5	33.3 50 30	>23,000,000	7.0	117	306
	11:00A 1-8-51		1	9.6	22.5 22.5 20.0 18.0		6.8	550	296
	10:30A 1-11-51		4	7.9	70 68.7 78 82		-	295	336
Ark. River at Hwy. bridge above Las Animas (mileage from mouth - 1175)	9:05A 12-5-50		1	11.6	11 10	36	6.5	160	268
	9:05A 12-6-50		0	10.9	6 3	0	6.0	51	306
	8:50A 12-7-50		1	10.8	6.4	93,000	6.0	37	314
	9:40A 12-27-50		1	12.8	2.9 3.0 3.8 3.2	-	6.6	26	268

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River at Hwy. bridge above Las Animas (mileage from mouth - 1175)	8:55A 12-28-50		0	-	2.5		5.5 2.2	16	246
	9:10A 12-29-50		2	12.4	2.6 2.3 3.4 3.8		6.0	22	254
Ark. River 2 miles below Las Animas (mileage from mouth - 1172)	9:45 12-5-50		1	12.4	3 2	36	6.5	145	288
	9:25A 12-6-50		0	12.2	2 2	210,000	6.0	15	322
	12-7-50		0	12.2	2.8 1.6 5.0 1.0	9,300	6.5	14	298
	10:00A 12-27-50		1	13.8	1.3 1.4 1.6 2.0		6.0	21	272
	9:15A 12-28-51		1	-	1.1 1.3 1.4 1.6		6.6	18	262
	9:30A 12-29-50		3	13.3	0.8 0.6 1.6 1.0		6.5	20.5	254
Ark. River at Hwy. bridge north of Lamar (mileage from mouth - 1135.6)	10:35A 12-5-50		1	12.6	2 1	0	6.5	20	272
	10:15A 12-6-50		1	11.5	3 4	36	6.0	20	292
	9:50A 12-7-50		1	11.4	2.4 1.2	430	6.8	10	297
	10:45A 12-27-50		2	13.1	1.8 .7 .4		6.5	22	278

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River at Hwy. bridge north of Lamar (mileage from mouth - 1135.6)	9:55A 12-28-50		2	-	1.4 1.2 1.6 1.4		6.0	30	254
	10:10A 12-29-50		3	13.0	1.7 1.4 2.2 2.0		6.5	27	258
Ark. River at bridge on Hwy. 196 and below Lamar (mileage from mouth - 1133)	12:30P 12-5-50			12.0	4 3		6.5	27	310
	10:35A 12-6-50		1	9.7	5 6 4 5	210,000	5.5	15	322
	10:15A 12-7-50		1	9.9	3.6 4.8 4.0 4.0	930,000	6.5	32	316
	11:05A 12-27-50		2	12.1	1.2 1.4 2.0 1.6		6.5	23	278
	9:25A 12-28-50		2	-	2.1 2.3 1.8 2.0		6.5	15	262
	10:30A 12-29-50		3	15.6	6.8 3.2 4.8 4.2		6.8	19	244
Ark. River at Hwy. bridge 6 miles above Holly (mileage from mouth - 1103.4)	11:35A 12-5-50		0	13.4	1 1	36	6.3	24	304
	11:05A 12-6-50		0	11.4	5 3	230	6.0	15	328
	11:45A 12-7-50		0	10.8	3.2 3.4	1,500	6.0	38	320
	11:30A 12-27-50		3	13.1	1.4 1.3 .8 1.2		6.0	38	270

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Ark. River at Hwy. bridge 6 miles above Holly (mileage from mouth - 1103.4)	10:50A 12-28-50		1	-	1.1 .8 1.6 1.4		6.0	26.5	256
	10:50A 12-29-50		3	13.2	8.8 0.6 0.6		6.5	35	270
Ark. River on Hwy. 89 one mile below Holly (mileage from mouth - 1102)	11:50A 12-5-50		2	12.3	10 2	91	6.5	27	270
	11:20A 12-6-50		2	11.9	4 3 8 8	91	6.0	39	294
	11:05A 12-7-50		2	11.6	1.2 1.2 4.0 1.0	750	6.5	39	308
	11:50A 12-27-50		3	13.0	1.1 1.4 1.8 1.8		6.5	23	258
	11:05A 12-28-50		2	-	1.0 1.2 .8 .8		6.5	47.5	256
	11:15A 12-29-50		4	12.7	0.7 0.7 0.6 0.6		6.5	35	256
Purgatoire Riv. at Trinidad and above sewer outfall	9:20A 12-12-50		4	11.2	0.3 0.2	0	5.8	18	228
	10:55A 12-14-50		3	11.5	0.1	0	5.5	10	214
	11:40A 12-18-50		2	11.5	1.1 0.4	0	6.0	8.8	220
	11:15A 1-3-51		1	11.2	1.1 1.1	-	5.5	19.5	226
	11:50A 1-4-51		1	11.5	1.7 1.7	-	6.5	36	232

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Purgatoire Riv. 1 mile below Trinidad outfall	9:40A 12-12-50		8	11	5.8 8.4 12.4 11.6	390,000	6.0	21	226.8
	11:15A 12-14-50		7	13.2	4.5 4.5 4.0 3.8	15,000	6.0	12	296
	12:01P 12-18-50		3	13.1	2.2 2.4 4.4 4.0	750	6.0	15.7	332
	11:35A 1-3-51		7	8.9	3.1 3.2 2.6	-	5.5	20	296
	12:10P 1-4-51		5	9.3	5.3 5.7 5.4 5.0		6.5	32.5	282
Cucharas River at Hwy. bridge north of LaVeta	11:40A 12-12-50		8	12.3	0.8 0.9	230	5.5	2.4	318
	8:25A 12-14-50		1	11.9	0.9 0.6	430	5.5	10	314
	9:45A 12-18-50		1	12.4	2.0 2.1	91	6.0	35	298
	9:10A 1-3-51		1	11.0	1.2 0.9	-	6.0	22.5	314
	9:35A 1-4-51		1	11.6	1.0 1.1	-	6.5	10	310
Cucharas River 2 miles below LaVeta	12:30P 12-12-50		8	12.0	1.6 1.4 3.2 2.8	2,300	5.8	4.9	274
	8:40A 12-14-50		1	11.3	1.7 1.8 1.8 1.0	9,300	6.0	10.5	274

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Cucharas River 2 miles below LaVeta	10:00A 12-18-50		2	14.8	2.1 2.0 2.2 2.6	430	6.0	17.5	251
	9:25A 1-3-51		1	11.6	1.9		6.0	22.5	302
	9:55A 1-4-51		1	12.6	1.9 1.8		6.0	11.5	282
Cucharas River above Walsen Camp	12:01P 12-12-50		9	10.9	1 0.8	0	6.0	8.8	228
	9:10A 12-14-50		8	7.1	1.0 1.2	36	8.0	7	1376
	10:25A 12-18-50		10	11.8	4.5 5.7	930	7.5	17	1186
	9:55A 1-3-50		1	11.5	3.4 3.4		6.5	16	372
	10:25A 1-4-51		1	12.7	1.2 1.1		6.0	10.5	292
Cucharas River at Walsenburg above sewer outfall	12:15P 12-12-50		17	8.4	2.4 2.4	430	7.0	7.5	1282
	9:30A 12-14-50		9	9.2	1.0 1.0	230	7.5	7.0	1212
	10:35A 12-18-50		1	9.3	1.8 1.7	930	7.0	15	1136
	10:05A 1-3-51		6	10.0	> 6.6		8.5	16	1228
	10:45A 1-4-51		11	9.3	1.6 1.9		8.0	11.5	1616
Cucharas River one mile below Walsenburg outfall	12:30P 12-12-50		13	4.4	>27.2 >27.2 68 66	>23,000,000	6.0	26	446
	9:50A 12-14-50		6	6.6	35 35 44 42	>23,000,000	6.5	27	404

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Cucharas River one mile below Walsenburg outfall	10:50A 12-18-50		8	5.9	74 72 80	21,000,000	6.8	38	444
	10:20A 1-3-51		1	8.8	14 12 13.3 20		7.0	23.5	796
	11:00A 1-4-51		1	9.4	6 4 6.7		7.0	16	568
Fountain Creek 50 yds. above Colo. Springs sewer outfall	10:00A 12-15-50		4	11.6	1.7 1.7 2.5 2.3	430	6.0	25	170
	8:40A 12-19-50		3	11.4	.8 1.4 1.4 1.4	91	5.0	12.2	192
	9:55A 12-20-51		3	12.2	0.9 0.8	280	5.0	23	162
	11:30A 1-2-51		3	12.7	1.6 1.6		5.5	22.5	160
	9:45A 1-5-51		3	12.2	1.3 1.4		6.0	12.5	164
Irrigation ditch 50 yds. below Colo. Springs sewer outfall	10:05A 12-15-50		9	6.8	70 68 73.3 76.6	230	6.0	32.5	160
	8:50A 12-19-50		8	5.8	98 96 110 106.7	21,000	5.0	26	150
	9:45A 12-20-50		8	7.4	72.8 71.0 91.9 88	930	5.5	27	164
	11:20A 1-2-51		6	7.6	96.6 93.3		6.5	15	176

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Irrigation ditch 50 yds. below Colo. Springs sewer outfall	9:35A 1-5-51		7	6.8	60 58 66.6 73.3		6.0	34	182
Fountain Creek at Fountain	10:50A 12-15-50		4	10.2	3.2 2.8 2.0 1.6	230	6.0	29	200
	9:20A 12-19-50		1	11.2	.2 .8 1.2 .6	2,300	5.5	13.8	216
	9:20A 12-20-50		1	11.0	4.9 5.2	9,300	5.0	32	198
	10:53A 1-2-51		1	10.9	6.4 6.8		6.0	35	200
	9:51A 1-5-51		1	10.0	5.6 5.4		6.5	26	196
Fountain Creek at bridge south of Fountain	11:05A 12-15-50		4	10.9	10 6 2	4,300	6.0	27.5	194
	9:30A 12-19-50		1	10.2	2 2 6	2,300	5.5	14.0	210
	9:05A 12-20-50		1	9.1	3.6 3.6 2.5 3.0	7,500	5.0	20	204
	10:45A 1-2-51		2	.6	3.6 2.8 3.8 3.2		6.0	15	214
	9:05A 1-5-51		1	11.2	7.0 7.2 7.2 5.2		6.5	34	200

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Salt Creek above C.F.&I. plant	2:16P 11-13-50			10.0	1.3	430	7.0	1.5	205
	8:15A 11-14-50			8.7	1.1	0	7.0	12.1	190
	8:05A 11-15-50			9.0	.4	30	6.7	7.1	191
	8:10A 11-16-50			9.8	5.7	430	5.0	3.9	190
	8:10A 11-17-50			9.1	.7	30	7.0	2.9	194
Coke plant outfall C.F.&I. plant	1:15P 11-13-50			3.8	>11.6	2,300	7.0	1000	148
	8:30A 11-14-50			2.3	>12.8	23,000	6.5	3000	171
	8:20A 11-15-50			2.6	>11.4	230,000	6.5	1500	148
	2:30P 11-15-50			4.1	> 9.8	2,300	6.5	2500	159
	8:25A 11-16-50			4.1	>10.8	9,300	6.5	1000	157
	2:45P 11-16-50			4.4	>11.4	43,000	6.5	600	163
	8:25A 11-17-50			3.7	>11.8	23,000	7.0	850	134
	11-29-50				>24.8 >65				
	11-30-50				>20.4 >61				
	12-1-50				>26.4 >73				
Main sewer outfall C.F.&I. plant	1:45P 11-13-50			7.2	2.5	23,000	7.0	3.9	156

Table 2a (Cont'd)

Sampling point	Date	Ave. disch. c.f.s.	Temp. °C	D.O. p.p.m.	5-day B.O.D. p.p.m.	Coliforms M.P.N. per 100 ml.	pH	Turb. p.p.m.	Alkal. p.p.m.
Main sewer outfall C.F.&I. plant	9:50A 11-14-50			6.3	.2	430,000	6.5	22.5	148
	8:40A 11-15-50			6.5	1.8	230,000	6.0	8.9	146
	2:45P 11-15-50			6.8	1.9	93,000	6.0	32.5	155
	8:50A 11-16-50			7.5	.9	9,300	6.0	12.2	151
	3:15P 11-16-50			6.7	5.0	39,000	6.0	12.6	150
	8:40A 11-17-50			6.3	5.9	43,000	6.8	37.0	120
	11-29-50				5.8 5.04 2.6 3.04				
Salt Creek below C.F.&I. plant and near confluence with Ark. Riv.	3:30P 11-13-50			4.2	10.4	43,000	6.5	340	152
	9:45A 11-14-50			3.1	10.8	150,000	7.0	700	146
	9:15A 11-15-50			5.1	11.0	75,000	7.0	235	152
	9:30A 11-16-50			4.6	12.0	64,000	6.0	320	153
	9:10A 11-17-50			4.0	13.6	43,000	6.5	430	151

Note: Discharge data not complete for inclusion herein, to be furnished as an addendum.